EDUCATIONAL TECHNOLOGY: INFORMATION NETWORKS, MARKETS AND INNOVATION

by

W. Curtiss Priest
Director
Center for Information Technology and Society

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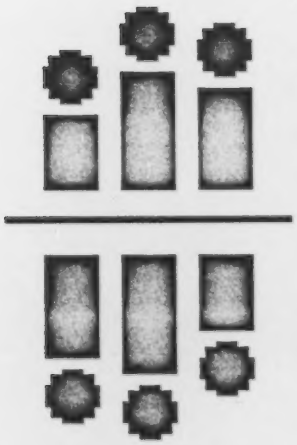
Center for Information Technology and Society

EDUCATIONAL TECHNOLOGY: INFORMATION NETWORKS, MARKETS AND INNOVATION

PART I

General Framework on
Markets, Nonprofits, Patrons
and
Policy



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W. Curtiss Priest, Director
18 Whipple Rd.
Lexington, MA 02173
617-862-7763

Part I — *General Framework on Markets, Nonprofits, Patrons, and Policy*

Part II — *Information Networks: The Diffusion of Innovation and Highlights of Discussions with Eighteen Networks of Teachers, Administrators, State Coordinators and Other Information Providers*

Part III — *Survey of Ten Educational Software Firms: A Study of the Economics of the Market and the Process of Technological Innovation*

Part IV — *A Survey of Four Firms Involved in Both Educational Software and Business Products*

Part V — *Reference Materials: A Comprehensive Bibliography on Educational Technology, Innovation, Adoption, and Policy* and Appendices

A Center for encouraging the growth and development of information technology for social needs including improved systems for learning, health, and governance.

GENERAL FRAMEWORK ON MARKETS, NONPROFITS, PATRONS AND POLICY

INTRODUCTION

The general aim of this report is to provide some insight about 1) reasons why educational markets are underproducing educational software, and 2) what thoughtful, practical remedies can be employed to bring the production of educational software up to the socially desirable (socially efficient, pareto optimal) level.

There are three overarching messages of this report:

I. **Leadership.** The problem of teacher training in using the new technology is only a symptom of a larger problem — the **lack of direction and leadership in American Education**. There too few leaders with vision and the ones that exist are underfunded, understaffed, and lack the backing of today's political leaders.

II. **National Purpose.** The lack of direction and leadership in American Education is a symptom of **a failure of purpose in America**. As *Perspective on Educational Technologies and American Education* in Part V of this report details, our country was born out of a quest for important values that we see embodied in the Constitution and in the progress of this nation. Economically we are in the mature stages of an industrial era and only **backing into** vitally new areas of

innovation and growth involving information technology. It is necessary to firmly embrace this move as a mainstream national focus of this country before local schools can receive sufficient voice from parents, teachers and administrators to bring the spirit and financial resources needed to make the software educational market viable.

III. **Connection.** There exists already decades of concern for problems of educating children, economic vitality, social ills such as divorce and child abuse, and foreign relations. What is needed is to **make the connection** between these political concerns and the capability of the new information technologies. With this connection, there could be an overnight change in this country's approach to the technology and the next wave of American Industry would be brought to its feet. This takes **placing faith** in the possibilities of the new technology (both present and future) and, unlike previous industrial activities, requires a **greater degree of wisdom** on the "demand" side of the market.

IV. **Focus.** In this era of letting the marketplace decide America's direction it is necessary to conclusively show why the marketplace fails to bring educational software in particular, and information technology in general, into full stride for social wellbeing. Toward that end, this report carefully identifies and demonstrates the specific sources of market failure and, in particular, labels the causes of these

"diseases" of the marketplace so that they can be formally recognized by those who will decide to allocate resources and can be "cured."

To develop the fourth point the discussion will turn to the way markets are supposed to work and then to the *diseases* — forms of market failure. Then, the discussion turns to a framework for viewing institutional responses to market failure including the roles of *nonprofit organzations* (such as local schools and educational software consortia) and *patrons* (such as government).

Turning to policy, the discussion then focusses on traditional approaches to remedying market failure with examples from the U.S. and abroad. Following this, policy options most suited to the area of education and educational software are identified, and their feasibility discussed.

THE WAY MARKETS ARE SUPPOSED TO WORK

Our adherence to a free and open market system of an economy has *generally* been proven to be an effective and powerful policy. The basic goal in any economy is to allocate resources — people and capital, to their most productive use. Any time a resource is directed to a more efficient use this is a "Pareto improvement" and everyone (in general) is better off. A society where all resources are actually applied to their most productive use is "Pareto-optimal."

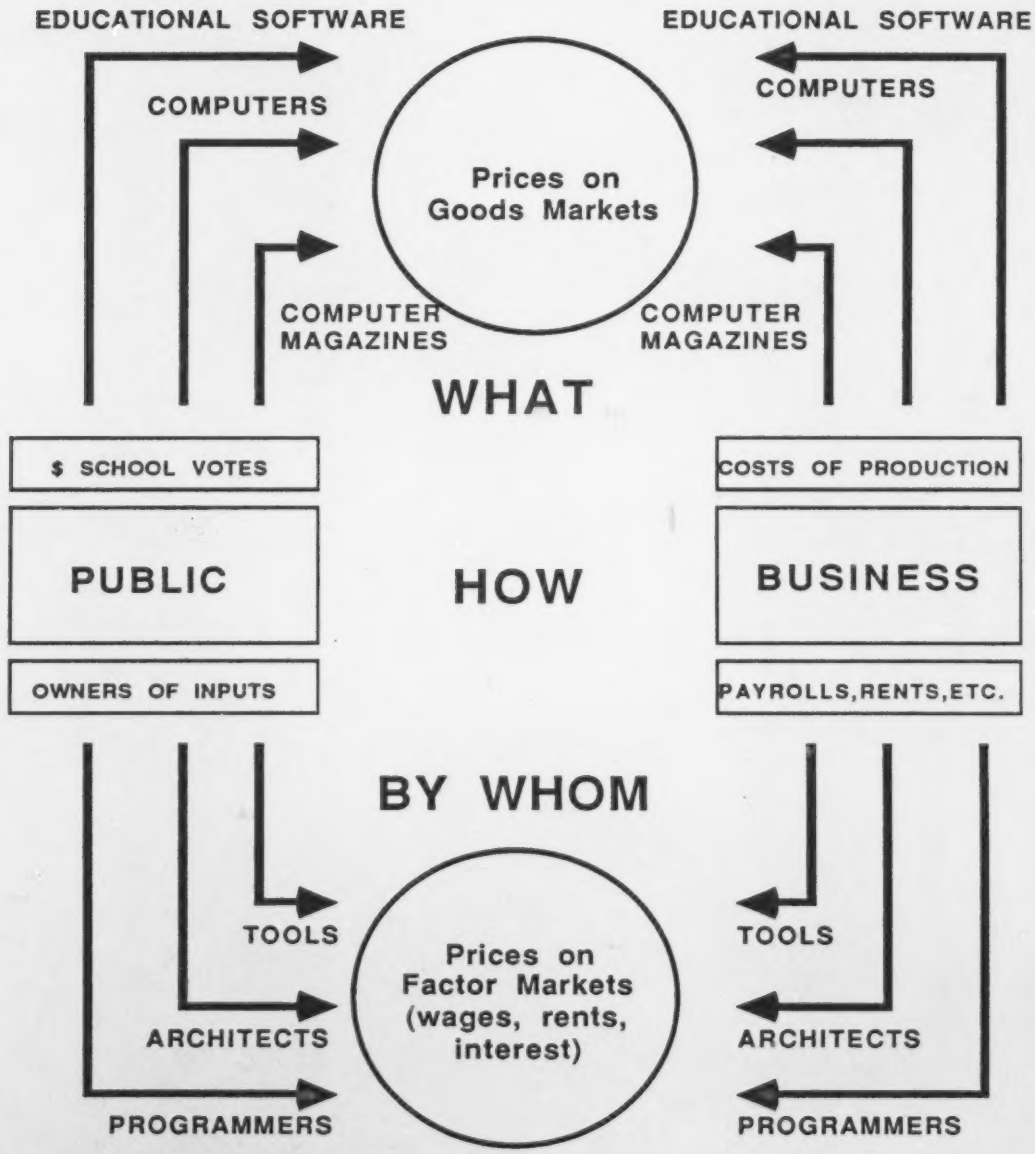
Samuelson [1973] illustrated well the operation of the market and an adapted version of this is shown as the next figure entitled *Competitive*

Price System for Educational Software. In the market, prices on goods coordinate the allocation of business activities and public expenditures. Basically, if the price is sufficiently high a firm is attracted into selling a product (or service) and if the price is sufficiently low a buyer is attracted in purchasing the product. Where prices are both high enough to attract supply and low enough to attract demand, the market serves to transfer goods from seller to buyer. "Factor prices" — peoples' salaries, rents on facilities, etc., in parallel to the action of prices on goods, serves to coordinate the allocation of resources. If the price on a factor (an input to production) is sufficiently low, a manufacturer is attracted in procuring the input (e.g. hiring a person) and if the price on a factor is sufficiently high to attract the input (e.g. a person interested in being hired.)

The virtue of this system is that it requires little external coordination. Each party, out of their own self interest, makes decisions about buying, selling, obtaining an input, or "becoming an input." Further, when there are many buyers and many sellers, competition will keep firm profits to a socially acceptable level.

The caveat to this system is that everyone must have perfect knowledge, be fully able to judge the value of products in dollar terms, and there must be no "spill-over" effects like, for example, air pollution. Actually, there are nineteen ways identified in this report that something with this system can go wrong — situations where the action of the market does not lead to the Pareto optimal distribution of goods. When any of these occur there exists **market failure**.

Competitive Price System for Educational Software



Center for Information Technololgy and Society, 1987
Adapted from Samuelson, 1973

Further, it is precisely in the area of educational software that there is a preponderance of market failure and for two major reasons: 1) there are characteristics of software as a commodity that makes it more susceptible to market failure, **and** 2) there are characteristics of education that make the educational market more susceptible to market failure. Together, the opportunity for market failure is enormous.

EDUCATIONAL SOFTWARE AND MARKET FAILURE

Review of the Literature

Market failure is the reluctant subject of economics. This occurs because so much of economics is a market oriented discipline and market failure as a subject is synonomous to discussing the *failure of market-economics as a field of study*. As a result, only public finance and some aspects of welfare economics have formed the basic literature in market failure. The recognition of some of these date back to the mid 1920's when Pigou [1924], and Marshall before him, recognized that knowledge provided benefits to society as well as to the purchaser. The recognition of externalties of information and knowledge was continued by Vier[1931], Meade[1952], and Scitovsky [1954]. A key early work was by Bator [1958] entitled *The Anatomy of Market Failure"*, and in 1962 Arrow [1971] was one of the first to identify three forms of market failures associated with information (indivisibilities, inappropriability, and uncertainty) when he addressed *Economic Welfare and the Allocation of Resources for Invention.* Braunstein [1976a,1976b,1979,1981a,1981b]

was one of the few early economists to generally treat the market failure of information as a commodity. Others who have addressed information as a commodity and the subject of market failure include Hall [1981], Levitan [1982], Mackaay [1982], Cooper [1983], and Priest [1984a,1984b,1985]. A useful reference in the field, generally, is Singer [1972] *Public Microeconomics*.

Advances in understanding market failure have had three major areas of focus. The earliest one relates to the study of invention and patents. In addition to Arrow's work, Nordhaus [1969] produced a seminal work on welfare and invention. The second focus was a large level of effort performed in the 1970's on the economics of social legislation and social regulation. Much of this legislation was justified on the basis of market failure, expecially the existence of *negative externalities* and *intangibilities*. Most recently, with the interest in privatization of public services, works have appeared such as Nelson [1987] *Roles of Government in a Mixed Economy* and Sappington and Stiglitz's [1987] *Privatization, Information and Incentives*. Another key recent work is the edited collection by Susan Rose-Ackerman [1986] on the economics of nonprofit institutions, and especially the article by Hansmann [1986]. In the area of market failure and education, Murnane and Nelson [1984] addressed the production and innovation when techniques are tacit (a concept parallel to *intangibility*) Additional selected references on the Economics of Information appear in Part V of the report.

Nineteen Forms of Educational Software Market Failure

The nineteen forms of market failure discussed in this section are failures in the market **for** educational software. There are also market failures in the supply of inputs to production of educational software firms which are addressed later.

Introduction

Prof. Debora Stone (currently a political scientist at Brandeis University) made the point at an MIT seminar that until a societal ill is formally named in a way that draws concerted attention to it, it is not likely to receive recognition or attention. Her example was the alcoholic. Only when alcoholism was designated as a disease and therefore worthy of attention by the health and business community could programs and cures be promoted. The social problem was the same but the name was changed to match the perceptions that it was treatable.

In analogy, the nineteen forms of market failure can also be viewed as diseases — to the organisms of U.S. Education and U.S. Society. Indeed, it was the early recognition of the *public good* aspects of education, and other forms of market failure, that public education became the activity of local and state government. The early recognition that education was not something that could be left to the private market and the persistence of this belief is the best evidence we have of the existence of market failure in education markets.

To further help in the formal designation of these "diseases" the following discussion introduces some more common names for areas of market failure than names currently used in economics. For example,

intergenerational transfers is called *legacy*, concern for positive externalities is called *veneration*, and inappropriability in terms of software piracy is called *theft*. While it might not be possible to arouse political support over inappropriability, it is if it is called *piracy* or *theft*.

The Nineteen Forms of Market Failure

The following list summarizes the nineteen forms showing a common name, the economic name, and a brief description of the concept:

- **Tragedy of the Commons**
  Public Goods: can there be simultaneity of ownership and difficulty in exclusion?
- **Theft of Product (Piracy)**
  Inappropriability: can the seller exact payment for the item's use or value?
- **Theft of Innovation**
  Inappropriability: can the developer maintain rights to the innovation?
- **Donations Discouraged**
  Price Discrimination: can differences in consumer surplus by captured in the price?
- **Commerce Discouraged**
  Nondepletability: does consumption lead to depletion of the item?
- **Low Veneration (Unsanctified)**
  Externalities: – are there benefits (or costs) to society that are not captured in the selling price?
- **Wasteful**
  Indivisibilities of Supply: is it difficult to separate the product into pieces of the size consumers wish to purchase?
- **Monopoly Priced**
  Economies of Scale: do decreasing costs of production lead to natural monopolies and artificially high prices?
- **Unapproachable**
  Risk and Uncertainty: is the market predictable?

- **Ignorance**

  Search: is it difficult to provide (or obtain) information about products?

- **Poor Wisdom**

  Bounded Rationalty: is it difficult for buyers to relate the product to their tasks and needs?

- **Underserved Needs**

  Information on Utility Functions: is it difficult for firms to learn about buyer preferences?

- **Unfair Trade Practice**

  Information Asymmetries: Are there reasons firms may purposefully withhold information about their products?

- **Vulnerable to Theft**

  Information Transfers Good (problems in allienation): In trying to reduce the problems of search does the provision of information about the good serve to provide the potential buyer with the good?

- **Low Perceived Value (Unappreciation)**

  Intangibility: can the benefits derived from a product be evaluated in dollar terms?

- **School System Hindrance**

  Transaction Costs: is it difficult to contract with many buyers?

- **Duplication of Effort**

  Aggregate Overinvestment and Lack of Standards: would coordination of development result in less duplication and greater aggregate efficiency?

- **Poor Legacy**

  Intergenerational transfers: are the benefits to future generations considered?

- **Poor Equity**

  Equity: are the distributional consequences of the availability of a new product received by individuals of varying wealth and background equitable and fair?

Economic Background. In a short space it is not possible to describe all of the economic concepts related to markets and market-failure. To provide some common reference, however, the following terms are germaine:

Allocating Resources -- Using labor, raw materials and capital in production
Efficiency -- Allocating resources to their most valuable use (also called allocative-efficiency)
Pareto Optimality -- The condition where all resources are allocated to their most valuable use

Pareto-move -- a change in allocation that increases the net value to society
Market-failure -- a situation where the operation of markets will not result in pareto-optimality or the fair distribution of wealth
Perfect Competition -- many producers and many buyers, where no individual producer or buyer can affect price; the absence of market-failure in a competing market
Imperfect Competition -- competition under forms of market-failure
Good -- Something bought and sold
Consumptive Good -- A good that is acquired mainly to be consumed
Instrumental Good -- A good that is acquired mainly for its co-productive capacity
Marginal -- the last unit of production or consumption
Marginal Cost Pricing -- Usually a firm operates where: marginal cost (the cost of producing the last unit) equals the market price for that good (Stated as MC=P)
Marginal Utility -- The utility derived from the last unit of a good
Rate-of-Return -- The income (or benefit) derived from an investment (Typically expressed as a percentage of the original investment)
Consumer Surplus -- Refers to either the individual or aggregate amount by which the benefits derived from the good exceeds its selling price
Utility Function -- Refers to either individual or aggregate preferences of the buyers. A utility function is a representation of the utility of a product or products.

Public Goods

Public goods include goods like national defense, parks, and lighthouses. They are goods that multiple consumers can enjoy at the same time (sometimes referred to as jointness-of-consumption). Computer software and information in general have the characteristics of a public good -- the use by one consumer does not prevent the use by others.

Public goods are often provided by government. Since consumers cannot be excluded from enjoying the benefits of a public good, use of tax-payer money to supply the good can be often justified. Economists and public administrators are quick to point out that government is not obligated to provide all public goods -- there are situations where the waste and distortion of government in trying to counteract the market failure results in more inefficiency than the original inefficiency [cf. Machlup, 1984, p. 157].

The market failure associated with public goods relates to the concept of marginal-cost-pricing described above. For maximum profit and maximum social efficiency, the firm should set the price of the good equal to the cost of producing the last unit (P=MC). But for a pure public good the cost of the last unit is zero and the firm should charge nothing at all. Thus for public goods social efficiency and private efficiency diverge. Pareto-optimality would be achieved only if the good were given away but then no firm could stay in business to produce it. (Baumol and Ordover suggest that the analysis is not this simple. "Resource allocation may benefit by the imposition of positive prices for public goods in cases where such prices are collectable" [1975, p. 1]). One common prescription for the situation is to have government subsidize the firm to an amount equal to the cost of creating the information. Another is to have government supply the good.

In summary, we can define the public good characteristic of education and software as:

> Public Good Characteristic of Education and Educational Software -- 1) The benefits that accrue to society of a generally educated population have the property of a public good — individuals cannot be excluded from deriving the benefit, and 2) The same educational software can be used by many students without interference and social efficiency would be achieved by producing it at marginal cost.

> The common name **tragedy of the commons** reflects the classical problem of the commons where all sheep herders let their cattle graze. With the common benefits of the commons and difficulty in exclusion, the commons would be overgrazed and everyone would lose. The commons was a classic public good.

It will help to explore four closely related problems -- inappropriability, nondepletability, externality, and intangibility.

Inappropriability. The term inappropriability is from the word appropriate. To appropriate something is to take possession for use by oneself. In the economic sense, it means to be able to take possession of the worth of something -- typically by selling it at the market price. Inappropriability is the difficulty in taking possession of the worth of something.

As indicated in the public good discussion, there is difficulty in excluding people from using education and software who have not paid for it. This occurs in two basic ways:

> Exclusion #1 -- Materials such as software are often passed along or shared. This is particularly the case when they are provided by libraries or rentals. Fifty percent of computer software is copied [Frazier, 1985].

> Exclusion #2 -- The information contained in any one material often represents the embodiment of prior work. For example, a software package on anatomy may borrow substantially from the contents of an anatomy textbook without compensating the textbook publisher.

The major result of inappropriability is under-production of education and educational software. If the producer cannot appropriate its full market value the producer will only produce information where he can recover costs and make a profit. This results in fewer software packages, books, etc. than is socially efficient (all other things being equal). Further, the types of information that are produced are distorted toward those types that can be subject to exclusion.

In summary, we can define the inappropriability characteristic of information as:

> Inappropriability of Information -- The difficulty in receiving full market compensation for the creation of information due to the problem of exclusion. The result is under-production and under-compensation.
>
> The common name **theft of inovation** refers to the problem of an innovator not being able to capture the full value of the innovation. For example, the invention of a new form of learning environment that uniquely combines structured knowledge and video display may not be patentable nor copyrightable beyond the specific text employed in the database and the specific images displayed in the video. The basic invention of the combination of these elements may be unprotectable under law and therefore unappropriable. (The recent decision by the courts in the case of a suit brought by Broderbund has ruled that the *look and feel* of a software package is protected under copyright, thus affording developers with some additional protection and appropriability.)
>
> The common name **theft of product (piracy)** refers to the particular problem with the ease with which computer software can be copied. A related problem is being **vulnerable to theft** (discussed below).
>
> In theory, a number of other problems in the list are technically forms of inappropriability but are discussed separately to distinguish them from **theft**.

Problems of appropriability have been recognized by Arrow [1962, 1971], Boulding [1971], Braunstein [1976, 1981], Cleveland[1982], Gordon [1982], Hall [1981], Macklup [1962, 1984], O'Brien [1980], and Priest [1984a, 1984b], and in inventive activity by Dutton [1984], Nordhaus [1969], Mansfield [1977], and Scherer [1977].

Price Discrimination. Recent theory in understanding the role of nonprofit insitutions [Hansmann, 1986] has revealed the importance of the nonprofit in being able to exact different

levels of payments for the services of the nonprofit. In the case of higher education, for example, the donations received by colleges by alumni are actually a form of price discrimination where some users of the service pay more than others. In opera, price discrimination takes the form of different levels of membership for attendance where the benefit of the differences are not as great as the difference in the willingness of the individual to pay for the good.

In summary, we can define the price discrimination problem related to education and software as:

> Price Discrimination Problem of Education and Educational Software -- the difficulty in achieving price discrimination to obtain a level of support for the service that more fully reflects the consumer surplus (see definitions above) of the buyers.
>
> The common name **donations discouraged** reflects those situations where due to market structure or the nature of the nonprofit institutions, donations are not encouraged to achieve price discrimination.
>
> Note: while involuntary price discrimination on the part of sellers (for the same good) is seen as unfair to consumers, in this instance we are referring to voluntary price discrimination where the buyer makes a choice to more fully reflect his or her own consumer surplus.

Nondepletability. Educational software and information, in general, is a very durable good. It does not dissipate with use. It may become less valuable when "better" software or information is generated but the original information is still present.

Computer software, information and knowledge can therefore accumulate over centuries and millennia. From society's standpoint this is a very positive characteristic but from a firm's standpoint this is a negative characteristic. A producer of educational software must not only compete with other present producers of software but also with all past producers. During periods like the twentieth century this is not an insurmountable problem because of the enormous increase in scientific and technological information, and the significant changes in media technology. Technically, the problem facing the firm is not one of direct market-failure but one of dwindling markets as in the case of any highly durable good. Nonetheless, it discourages commerce because of the constraint it places on profits and growth. Nondepletability leads to positive exernalities to society and is further discussed below.

In summary, we can define the problem associated with the nondepletability of educational software and information in general as:

> Nondepletability of Educational Software and Information -- Educational software and information do not dissipate with use. Producers must compete with past producers but society benefits with an accumulation of knowledge.
>
> The common name **commerce discouraged** refers to the problem where firms are discouraged from the market due to lower profit and growth potential.

Externality. If there is an effect associated with a good -- positive or negative -- that is not accounted for in its price, there is an externality present. For example, the polluting of a stream by a pulp and paper mill represents a negative externality. The production negatively affects others and the good is more cheaply produced than if the pollution were controlled. We refer to internalizing the externality if there is some way to have the firm more fully account for such effects. A set of water quality standards could be established that the mill must meet by law. The presence of negative externalities was a major impetus for health, safety, and environmental legislation.

Educational software, in contrast, has few negative externalities, but significant positive externalities. The knowledge that educational software imparts is carried along to producing many more worthwhile outcomes for the individual and society. The nondepletability character of information leads to positive externalities that extend for generations -- the "wealth of knowledge" that has accumulated over time (see intertemporal transfers).

To determine the value of a positive externality we can turn to cost/benefit analysis. Cooper [1983] reviews a number of C/B studies which include assessments of various information science activities. A study by Goddard assesses the benefits of public and school libraries. These libraries are seen as promoting education and therefore resulting in externalities in education -- the benefit to more than just the person being educated. Levin [1987] describes both public good and externality aspects of education.

The positive externalities of fine arts has been a subject of congressional debate for decades. For example, in introducing a bill in 1953 to establish a National War Memorial Arts Commission, Charles Howell of New Jersey said,"There is a philosophical difference in viewpoint which must be considered in the evolution of the measure I have sponsored. The debate is between the proponents of the belief that the arts are living and must be encouraged with every resource at hand, and those who regard the arts basically as the product of a past age, which must be preserved rather than encouraged" [Larson, 1983].

The positive externalities of science have been recognized in the massive support the government provides for it. Alvin Weinberg commented, "society expects science somehow to serve certain social goals outside science itself. It applies criteria from without science -- broadly, criteria concerned with human values -- when it assesses the proper role of science as a whole relative to other activities" [Reagan, 1969, p. 34]. Reagan reviewed congressional hearings, journals, and other sources and found five basic reasons for support of science (four of them externalities):

1. Intellectual and cultural values of science
2. The utility of basic research as the foundation of all technological development
3. Research as an essential component of graduate education
4. The high costs of scientific research, and the unlikelihood of adequate private financing (appropriability, risk, uncertainty)
5. The political values of science, especially in international affairs.

Positive externalities and appropriability are closely tied concepts. Whatever the producer of information cannot appropriate will be, by definition, a positive externality. The appropriability of invention has been a subject of considerable research.

Nordhaus [1969, 1985] estimated the ratio of marginal social product to marginal private product using data on American agriculture. He calculated ratios of 12.7 for 1949 and 8.5 for 1959. These ratios imply very high social rates of return on research and verify earlier work by Griliches on the magnitude of the rate of return on hybrid corn. I.e., Nordhaus found very high positive externalities to agricultural research.

Mansfield [1977] performed an empirical study on social and private rates of return from industrial innovation. For eighteen innovations the median private rate-of-return was 25% (before taxes) and the social rate-of-return was 56%. Mansfield's ratio of social to private return was 2.2. The highest social return was 307% for a "thread innovation" (private return of 27%) and the highest private return was 214% for a "household cleaning device" (social return of 209%).

Calculations of positive externalities, at best, are fraught with methodological difficulties. Thus these data should be considered suggestive of the possible externalities associated with educational software and other information resources. Since information is such a powerful producer of additional outcomes and benefits, comparisons to more common products are likely to greatly understate the level of externalities. (Furthermore, since all goods have some level of consumer surplus associated with them, it is only goods that have a disproportionate level of consumer surplus that manifest market failure.)

In summary, we can define externalities associated with information as:

> Positive Externalities of Educational Software and Information -- The benefits of educational software and information, that are not accounted for in its price.
>
> The common name **low veneration (unsanctified)** comes from the way goods with large positive externalities become appreciated in society through veneration over time. Education, moral training, virtues, and other cultural values are treated this way.

Externalities refers to the non-property aspect of information. Higher economic efficiency can be achieved by internalizing externalities, i.e., providing the producer of information greater appropriation. This can be achieved by the creation of property rights and corresponding payments to owners.

For educational technology and other information sources, however, the costs of "keeping book" (adding up who owes what to whom) are likely to be high, thwarting attempts at increasing the appropriability of externalities. Perhaps in the era of the information utility, where computer information systems can keep track of many minor transactions, full accounting will be possible by keeping track of what information is of use to whom. Before that, we must struggle with assuring that public outlays consider the externalities that accrue to the long term effects of educational software and information.

Intangibility. Thus far we have referred to the market price of information as some reflection of the marginal utility of information to the consumer. For simple consumptive goods (see definition above) the price of a good is a reasonable proxy for its marginal utility. For instrumental goods, such as educational software, information and knowledge, the price of the good may have little resemblance to its marginal utility.

This problem has been referred to as the inability to monetize (set a monetary value on) a particular good. For example, what is the monetary value of good health? Good Health is the co-producer of many desired outcomes -- it permits thinking, locomotion, stamina, etc. The impact of an acute illness, an illness of three months or less, may in some circumstances be monetized but the impact of chronic illness cannot be monetized [Priest, 1981].

What is the monetary value of education, libraries, guidance counseling, or church attendance? All of these activities involve substantial levels of information and all will be an increasing area of computer software activity.

Boulding [1971, p. 23] interprets the problem of intangibility as one of the problem of information measurement. "One longs, indeed, for a unit of knowledge, which perhaps might be

called a 'wit', analogous to the 'bit' as used in information theory; but up to now no practical unit has emerged."

The problem of intangibility and measurement relates back to the definition of information [see Priest, 1985]. Educational software and Information in general derives its utility by changing the efficiency of achieving outcomes by changing choices. An activity such as education involves millions of changes in potential choices. "Education produces possibilities." To faithfully arrive at the utility of education then I would have to consider two situations, the attainment of all outcomes without the education and the attainment of all outcomes with the education. I would have to measure the efficiency with which each outcome was achieved under the two conditions, and sum the efficiencies to attain a single value of merit. Further, I should perform this exercise, not after the impact of the education has been seen (ex post), but before (ex ante), because this is the circumstance in making the purchase. This means forecasting the efficiencies and outcomes under the two situations.

When a consumer is faced with purchasing education, however, it is exactly this calculation he must make to make the correct buying decision. But this is not how education is "sold." The U.S. adopted compulsory education for grades 1-12 because the value of the education was believed to be at least worth the cost (and effort). Much college education is purchased with the faith that the value of college education is at least worth the cost.

In summary, there are many forms of information, such as education, that affect a great many potential outcomes and are, therefore, largely non-monetizable. We can define intangibility of educational software and information as:

> Intangibility of Educational Software and Information -- The character of educational software and information to be non-monetizable.
>
> The common name **low perceived value (unappreciation)** was chosen as a result of interviews with educational software firms. *Perceived value* was the most common way respondents referred to the problem of intangibility.

Intangibile goods differ from so many other common goods. Other common goods are usually concrete and well defined. But something that is intangible is not. Specific components of education such as software, textbooks, filmstrips, and study guides can be copyrighted. But it is difficult to assess the value of these components, since they contribute to the "building process" of education. What is the value of a primer on the alphabet? What if another primer costs twice as much -- is it worth it? These questions have faced educators and others who have dealt with the intangibility of information.

Indivisibilities of supply

Educational software users are confronted with an all-or-nothing option: they may either acquire the whole amount of the software available at the prevailing price or buy no software at all (the same problem exists for information in general [Pethig, 1983]). At some level, all software and information is indivisible. Four years at college, a year, or a course can be purchased, but not a particular lecture. To have the editoral page of the New York Times the entire paper must be purchased. To have the telephone numbers of those I want to call, I have books mainly filled with the numbers of people I do not want to call. To have an educational software package on the verb *to be* I must purchase a package on many verbs.

Nonetheless, from an efficiency standpoint, purchasing unwanted commodities is wasteful and not allocatively efficient. And while the cost of reproducing a software program is almost identifical whether it contains one verb or 100, the market price would not be the same if marketing costs were not an obstacle.

A related problem is the organization and accessibility of information and knowledge. To obtain new information I must continually pour over old information in search for new. So not only do I incur the cost of purchase but also the opportunity cost of search.

In summary, we can define indivisibilities associated with the supply of educational software and information as:

> Indivisibilities of supply -- Educational software and information in general must be purchased in lumps; these lumps may be vastly greater than the learning or information actually sought.

> The common name **wasteful** describes the waste involved in purchasing something that will not be used.

Economies of Scale and Scope

For some goods, increasing a scale of operations results in decreasing costs per unit. This condition is called economies of scale and explains why so many of the goods we buy are produced by large companies.

As an example, Braunstein [1981] notes that daily newspapers have high set-up costs and low costs associated with the production of each copy printed. As a result, the vast majority of daily newspapers have no competing daily newspaper published in the same city.

Economies of scale are usually associated with production involving high set-up or fixed costs, decreasing unit costs, or both. If economies of scale are substantially present when the

output of the producer is equal to the total market demand, there is the condition of "natural monopoly." A monopoly in these cases can be more socially efficient than competing producers. Unfortunately, the monopoly can make higher profits by under-producing and thereby inflating prices [Samuelson, 1973]. Public policy towards this situation has been to permit the monopoly to exist but to regulate rates so that price equals average costs plus some reasonable return on investment for the stockholders. Typical regulated monopolies are local gas and electricity distribution companies and local telephone companies. (Regulated monopolies have also been criticised for being socially inefficient because 1) They have little incentive to minimize costs, and 2) They often display lower innovative capacity for new inventions, features, etc.)

Economies of scope arise when it costs less to produce several different products by the same firm. This can occur when one product utilizes a by-product of another or when both products draw from the same intermediate product. "Information, because it can be packaged in so many ways, is often produced or distributed under conditions of economies of scope [Braunstein, 1981, p. 59].

The presence of economies of scale and scope is often indicated by industry concentration -- the presence of fewer, larger producers. Homet [1984] finds the electronic information-delivery sector increasingly characterized by concentration. He notes that in 1980, fewer than 100 corporations controlled a majority share of each of the mass media: daily newspapers, periodicals, books, records and tapes, radio and television distribution and sponsorship, and movie distribution. "Cross-ownership trends among these media drew the net even tighter: Time, Inc., with book publishing and cable (not to mention HBO), Times-Mirror with TV and cable and videotex, CBS with book publishing and records and magazines" [Homet, 1984, p. 14].

Dertouzos and Wildman [1981] made a historical study of concentration in the recording industry. They found that the percentage of sales controlled by the top 4 firms declined from 1947 to 1972 from 79% to 48%. In 1972 a full 15% of sales were made by firms smaller than the largest fifty. But concentration in distribution and marketing of recordings has occurred as the major recording companies have increasingly been relied on by independent recording firms for distribution.

Evidence discussed in Part III indicates that the textbook industry also achieves economies of scale and scope through economies in marketing and horizontal integration. There is little evidence of economies of scale in the development of educational software and the market is too new to know what economies of scale in marketing exist.

In summary, we can define economy of scale and scope with regard to the production and distribution of educational software and information as:

> Economies of Scale and Scope -- 1) decreasing unit costs when the scale of operation is increased; and 2) decreasing costs associated with joint production.
>
> The common name **monopoly priced** more specifically focusses on the market failure problem associated with economies of scale and scope. If a market becomes dominated by one large firm (or even by a few large firms) prices may be inflated by the seller (monopoly profits) and the buyer will pay more for the good than is economically efficient.

Risk and Uncertainty in the Production of Educational Software

Risk has been termed a "mild uncertainty" [Nordhaus, 1969]. We are uncertain about which educational software project will succeed, but we are fairly confident that some will succeed. In some areas, however, there is not even sufficient experience to judge the probability of success. These are cases of full uncertainty. Research in cancer and interstellar communications are subject to large uncertainties.

If the risks and uncertainties are small, private investors will continue to produce. What they appropriate for the successful projects must cover not only the costs of the successful projects but also the costs of the unsuccessful projects. The costs of unsuccessful projects are part of the costs of doing business. When risks increase to the point that the producer lacks the ability to diversify enough to assure a success, the producer will withdraw. When there are sizeable uncertainties the producer will also withdraw because there is insufficient information to justify the activity to stockholders or other investors.

Under these conditions of risk and uncertainty, information will be under-produced. The problem is exacerbated when the size of firms in the industry is small. Smaller firms have less capacity to handle risk and uncertainty. In contrast, firms like IBM and AT&T can "afford" some ventures that a smaller firm could not. Unfortunately, larger firms also tend to be more risk averse than smaller firms -- that is, they require greater potential return to risky ventures than a smaller firm does. Whether the degree of risk averseness of the larger firm negates its greater capacity to absorb risks is a point of current debate.

If individual firms cannot bear risks or uncertainty, in some cases it is socially efficient that society do so. "In operational terms this implies that the government do all R&D or that the government have R&D done by firms or individuals on cost plus contracts" [McFetridge, 1977, p. 16]. Other mechanisms include partial subsidies and forgivable loans where the state bears part of

the risk associated with a given project. Finally, some projects are too risky or uncertain even for society to undertake.

The public policy response to risk and uncertainty is fraught with unknowns and debate. The social rate-of-return must be sufficient to justify the risk and uncertainty. Thus, government tends to support basic science and R&D to a lesser extent. The greater the potential "co-productive capacity" of the resulting information (see Priest [1985]), a cause of positive externalities, the more government involvement can be justified.

In summary, we define the risks and uncertainties in educational software production as:

> Uncertainty and Risk in Educational Software Production -- The inability of firms to produce educational software when risks and uncertainties are present. A problem, in particular, given the weak market for educational software and the lack of leadership for major efforts.
>
> The common name **unapproachable** captures the firm's inability to approach certain projects because of risk and uncertainty concerns.

For an extensive treatment of uncertainty in the production of information see Arrow [1962,1971].

Information

Search. The problems of "search" is a well known related topic in economics [cf. Kwon, 1982; Stigler, 1971]. Perfect competition presumes the presence of perfect information -- that all buyers are aware of all sellers, their products, their quality, and their prices. Perfect information does not typically exist and the result is potentially inefficient: some products may be purchased at too high a price for their level of quality, performance, service, etc.

Bounded Rationality. Once a potential buyer has identified a product, there is still the problem of whether the buyer can judge and assess the capacity of the product to meet the buyer's needs. Common commodities such as food and soap are easily assessed but educational software is more difficult to assess. The problem of bounded rationality becomes exacerbated as the buyer has less information about the product.

Information on Utility Functions. It was remarked by one producer of educational software that market surveys are not very useful because teachers are unable in advance to tell producers what they need. "Teachers know what they need when they see it." This problem of assessing utility functions makes producing educational software more difficult that producing other products. One solution to this is the presence of the *user-innovator* – teachers who become software producers (see Part III of this report on innovation).

Information Asymmetries. Anytime private information about a product or service exceed public information there is said to be information asymmetries. While the term is closely related to the problem of search it is often used for situations where it is in a firm's interest to **limit** the availability of information. Firms may wish to limit information when the quality of their products are inferior to others on the market.

Information Transfers Good. Arrow noted a fundamental paradox in the determination of demand for information, "its value for the purchaser is not known until he has the information, but then he has in effect acquired it without cost" [Arrow, 1971, p. 148]. If the seller could maintain property rights to the information this would not be a problem, but given problems of appropriability, "the potential buyer will base his decision to purchase information on less than optimal criteria [p. 148].

Educational software is not only subject to the problems of search but the problem is compounded by the appropriability problem discussed by Arrow. A producer of educational software will make software less accessible to the extent that it is not appropriable. But this inaccessibility greatly increases the problem of search. The less the buyer knows about a product, the less likely the buyer is to purchase it, or to purchase it at the "correct" price (the price under perfect competition).

To counteract this problem, producers of information rely on "brand recognition." Producers of information develop a reputation for the value of their information. For example, Standard & Poor is respected for its appraisals of the stability of firms and bond offerings.

This tendency raises again the issues of monopoly and concentration addressed above. It is difficult for a new entrant (a firm that attempts to sell in the new market) to succeed. Thus the problem leads to "barriers to entry" and greater industry concentration than would occur otherwise.

In summary, we can define the problems associated with information about educational software and information in general as:

> Search -- The difficulty in identifying and gathering evaluation data about educational software.
>
> The common name **ignorance** emphasizes the level of buyer ignorance when problems of search are great.
>
> Bounded Rationality -- The difficulty in assessing the suitability of educational software for educational purposes. (This problem is simiar to the problem of intangibility but relates more to *function* rather than *value.*

The common name **poor wisdom** emphasizes that buyers such as teachers that have poor wisdom about educational software display problems of bounded rationality.

Information on Utility Functions -- The difficulty for producers of educational software to identify what products buyers need.

The common name **underserved needs** emphasizes the likelihood that needs will not be met when information on utility functions is difficult to attain.

Information Asymmetries -- Problems of search due to firms intentionally withholding information about their product. This most often occurs regarding product quality.

The common name **unfair trade practice** reflects the unfairness of this activity to the consumer.

Information Transfers Good -- Information about educational software is less likely to be available because of appropriability problems. This leads to under-consumption of information due to problems of search.

The common name **vulnerable to theft** emphasizes the ease with which educational software and information can be copied when the seller is trying to make it available for evaluation and marketing in general.

Transaction Costs and Educational Software. Besen [1977, p. 87] notes, "[i]t is unfortunate that, in the economics literature, the term "transaction cost" is used to describe two quite different phenomena." In the first sense "... the term is applied to the costs involved when agreement must be reached among a large number of parties in order to carry out an activity. Transaction costs are said to be high in such situations because the free-rider problem raises the cost of reaching an agreement. A second meaning of the term involves the costs of negotiation, contracting, and enforcement ..." Sometimes the term is misapplied to mean "the cost of transmitting information which has already been produced" [cf. O'Brien, 1980, p. 452].

In this discussion we refer to the second meaning of the term. In this sense, transaction costs and indivisibilities (above) are related. As we attempt to reduce indivisibilities by breaking information into pieces, we increase transaction costs as we attempt to appropriate its value.

In summary, we can define transaction cost and educational software as:

Transaction Cost and Educational Software -- The additional costs incurred by the producer in appropriating value of educational software through negotiation, licensing and contracts.

The common name **school system hindrance** emphasizes the maze of problems software firms encounter in attempting to make sales in that market. The reason for this

maze is actually related to the intangibility of education itself. Unlike making a decision about tangible commodities, decisions about educational commodities involve groups of decision-makers that are required to reduce the chances of inappropriate choices. This very need to confer and discuss is what increases transaction costs to sellers. (In addition, there are bureaucratic conditions in school systems beyond those necessary to make informed decisions and these too add to the burden.)

Aggregate Overinvestment

Perhaps one of the most difficult sources of market failure to sort out is the extent there is aggregate overinvestment or duplication of effort. Kamien and Schwartz [1982] describe how "the race among the potential inventors to be first leads to aggregate overinvestment." And how "the absence of coordination among potential innovators may result in excessive duplication." The issue is difficult because of the bind between the encouragement of innovations from which social welfare increases are derived and the reduction of excessive duplication which also increases economic efficiency. Attempts to limit the second can limit the first.

A second problem is in identifying what is truly excessive duplication. Every product on the market is different in some way even if small. The presence of these different products increase consumer choice and the potential for better meeting utility functions of the buyers.

Nonetheless, there is a clear sense among educational software producers that there is excessive duplication in a number of areas (see Part III of the report). Ideally, instead of a great number of parallel software efforts it would be superior if each person's efforts built on the prior efforts of others. This does occur at the juncture of software tools and end-user software products because these two activities are separable and have different markets altogether. Other countries, such as France have been more successful in introducing a degree of central planning so as to overcome the problem of aggegate overinvestment. What is fairly clear is that there is a stage in the maturation of technology where the benefits of coordination can outweigh the loss of further innovation caused by the coordination.

One form of coordination is through the adoption of technical and professional standards. Indeed, this country has seen considerable success with reducing duplicative efforts by a large number of standards developed by the National Bureau of Standards, ANSI, and numerous other bodies. In the area of computers, communications protocols such as RS-232 have made an important difference in the ability to connect machines of different manufacture. The proposed ANSI standard for the C language will greatly improve the ability to transport educational software from one manufacture of microcomputer to another. There are also attempts to standardize the depiction of graphic information to facilitate the transfer of pictures between machines.

Whether firms themselves will develop standards themselves is a fascinating area of study. Prof. Marvin Sirbu of Carnegie Mellon University has been conducting a study of when firms do and don't develop standards themselves and under what circumstances. Some firms such as IBM have regularly shunned standards to prevent other firms from intruding on their customer base. Other manufacturers encourage standards because they widen the market for their products.

From a market failure standpoint, the absence of a technical standard usually leads to losses of economic efficiency.

The development of professional standards and requirements also can improve economic efficiency by overcoming other causes of market failure and producing economies of scale. For example, a number of states have required computer or keyboard literacy in their schools. This has overcome problems of teacher computer literacy (problems of *ignorance* and *poor wisdom*) by propelling teachers into the use of computers.

In summary we can define the problem of aggegate overinvestment and lack of standards as:

> Aggregate Overinvestment -- the overproduction of duplicative educational software
>
> Lack of Standards -- the need for technical or professional standards that would improve efficiency in the market.
>
> The common name **duplication of effort** covers both the problems of aggregate overinvestment and the lack of standards.

Intertemporal Transfers

Our society, like all other societies that have survived to this point in time, has survived by being concerned about the well being of future generations. In terms of John Rawls' notion of justice as fairness, where a group, under the "veil of ignorance" of not knowing what generation the negotiators will be in, are trying to decide how generations should treat other generations, it would be decided that earlier generations should invest in culture and tools for later generations because of the culmulative nature of such investments. (If this reasoning appears odd, the reader is heartily encouraged to read Rawls' 1972 book *Justice as Fairness*.

Educational software tools may be one of the greatest legacies an earlier generation can leave to later generations. If those tools embodied both the knowledge and the culture of what comprises good society, those tools could be of invaluable use to all future generations in maintaining a warm and prosperous society.

Nonetheless, investments that are beyond that which standard economics would dictate reduce the current welfare of any one generation. For this reason we have the concept of legacy which enobles the principle of leaving something to future generations.

There is a peculiar problem, however, with educational software, and technology in general, in that their very newness makes it difficult for society to view them as legacies. Only through strong leadership and wisdom will such legacies be taken seriously.

In summary, we can define intertemporal transfer concerns for educational software as:

> Intertemporal Transfers -- the wish of society to transfer some current wealth to the culmulative welfare of all future generations.
>
> The common name **poor legacy** emphasizes the neglect society may show in any generation to future generations especially involving new technologies which are not accorded the same sense of legacy as more traditional forms of legacy.

Equity

Concerns for equity and distributional consequences of many activities of society have been of continual concern to our society. In fact, in terms of legacy, the concern for equity and the results of our actions will be one of our major legacies to future generations.

At times, concerns for equity dwarf all other forms of public concern because of the high level of commitment shown by society over the last two centuries and especially within the last three decades. Unlike other social problems like pollution and consumer problems, the concern for equity has withstood political changes and remains a primary basis for government "intrusion" in the affairs of business and individuals.

Therefore, as we introduce new educational software that empowers students to learn better and get better jobs, the failure to distribute these advantages among all students is a serious broach of our equity concern.

In summary, we can define our concern for equity and educational software as:

> Equity and Educational Software-- The concern that all students have equal advantage from the benefits of the new technology.
>
> The common name **equity** is the same, partly because the word has been adopted by the discipline of economics from the concern of society in general.

EDUCATIONAL SOFTWARE AND NONPROFIT FAILURE

As will be more completely shown later, nonprofit organizations often arise in response to market failure and have been termed the third sector of the economy (in addition to the private and

public sectors). Before turning to the complete framework it is necessary to show a parallel set of forms of nonprofit failure.

Review of the Literature

As noted by the founders of the Yale *Program on Non-Profit Organizations*, this "third sector" has a very important role in the United States and yet has been the "least well studied, the least well understood of our national life." Thus, the literature is very modest and very recent. A key work is edited by Susan Rose-Ackerman [1986] as part of the Yale series of book publications. Of particular interest is Hansmann's [1986] sweeping article on the role of the nonprofit enterprise and several other articles on the economics of nonprofits including Easley & O'Hara [1986], Ben-Ner [1986], and Krashinsky [1986]. A further piece by Dennis Young of the Urban Institute [1986] provides an excellent review of the personality types that are attracted to nonprofit organizations. It is based on their work that the adaptation of Samuelson's figure at the beginning of this report calls the designers of educational software for schools — architects.

Seven Forms of Nonprofit Failure

Introduction

In parallel to the discussion on market failure, it is important, again, to name the forms of nonprofit failure so we can concentrate on the true sources of difficulties in receiving the benefits from educational software.

The seven forms of failure are "diseases" of the "organisms" we call nonprofits which include schools, universities, professional organizations, standards bodies, and research institutes. The very institutions that have arisen in response to market failure are subject to failure themselves. Some for the same reasons as market failure but some for reasons peculiar to the nonprofit itself.

The Seven Forms of Nonprofit Failure

- **Limitations on Raising Capital:** Nonprofits in general and schools in specific are not easily able to raise capital for major activities or acquisitions
- **Lower Incentive for Efficiency Due to Rigid Curricula:** Where teacher's job stability and advancement is dependent on evaluation within prescribed curricula, attempts to incorporate new technology threatens teachers' jobs and peer relations
- **Lower Incentive for Efficiency Due to Lack of Competitive Pressure to Use Technology:** In the business environment there is what Burton Klein of Cal Tech calls the "hidden foot" — competitors that do not keep pace are driven out of the market. There is not a similar impetus in the nonprofit sector.

- **Ignorance of Products**: As in the case of market failure, members of nonprofits have problems of search.
- **Ignorance of Outputs:** Nonprofits arise, in particular, where there are intangibilities — situations where outputs of the process are hard to determine or measure. While nonprofits are more trustworthy in producing the outputs they were given charge to manage, they still have difficulty in assessing these outputs and can fail to perform for lack of good information about the *quality* of them. (Note: one of the major reasons for the formation of nonprofits is to remedy problems of both intangibilities and information asymmetries when information on the quality of outputs is difficult to determine or when the receivers of the product or service, e.g., students, are not the buyers, e.g. tax paying parents, see further Hansmann [1986].
- **Lack of Wisdom (Bounded Rationality)**: Again in parallel to the problems of market failure, nonprofits can fail to correctly judge the suitability of educational software.
- **Lack of Voice (from Parents, Educators, and/or Patrons)**: The parallel to the price mechanism in markets is "voice" for nonprofit activity from those people who are concerned about the outputs. If these interested parties do not express their interests and concerns there can be failure in terms of the outputs of the nonprofit entity.

EDUCATIONAL SOFTWARE AND PATRON FAILURE

A third component of the complete framework includes the patron — the benefactor and white knight to market and nonprofit failure. Nonetheless, as with markets and nonprofits, the patron, too, is subject to failure. Thus we list the nine forms of patron failure before turning to the final framework.

Review of the Literature

Patrons include governments, private foundations, politicians, and leaders of many types. Patronage in the traditional sense primarily focuses on the support of the arts and culture. The literature of this type of patronage is extensive and includes Haskell [1963], Larson [1983], and Levine [1970]. A review of foundation philanthropy appeared by Goulden [1971] and patronage of the U.S. government for the sciences appeared by Miller [1970].

Patronage in a wider sense includes all of government and political activity. These are further treated in the ensuing section on policy.

Nine Forms of Patron Failure

- **Lack of Leadership/Vision due to Lack of Wisdom (Bounded Rationality)**: Our country has had many leaders of great vision throughout its history. Nonetheless, there are limits to

the wisdom of the "greatest" leaders and there are also times when society does not call forth great leaders.

- **Lack of Leadership/Vison due to Lack of Courage**: While it is certainly true that a leader needs courage, society, too, needs courage to provide leadership with support. Sometimes a leader has the gift to not only have a clear idea of what is needed but also the ability to raise the courage of the country in the pursuit of those goals.
- **Lack of Leadership due to Political Constraints**: A clear sense of purpose and the ability to mobilize the public is not sufficient to win elections or votes in Congress. There are interest groups of many persuasions and states of differing political needs. Further, government and other bodies usually have the capacity to focus on one orientation or another. Thus the swing of the political pendulum and the mood of the country have great influence on a potential leader's future.
- **Lack of Leadership due to Political Boundaries**: Education in particular has been the province of local and state government. Thus leadership at the national level is stymied by the inability to effect policy at the national level to influence the local political provinces of education. Leadership at the state and local level is more likely to have an influence but is also less likely to have the talent and support base to have a large effect. In the case of California, Governor Brown has been very influential within the state, however, that influence has only a secondary impact on the rest of the country.
- **Diversion to Other Important Issues**: Government and other bodies have a limited capacity to deal with a limited number of issues. If pressing issues such as foreign relations or a health epidemic are consuming, there is little opportunity to concentrate on more sweeping concerns.
- **Degree Moral Issues are Affected**: There are certain activities of patrons that are not burdened by complex moral issues. Feeding starving children or protecting national borders are fairly uncomplicarted goals. In contrast, education, in its broadest sense, is about learning and values, about purpose and behavior, etc. For example, the move toward "values clarification" stumbled across those who thought values clarification promoted questioning of sanctified values and threatened the fabric of society. Thus, to the degree that an area is morally complex, patronage failure will be more extent.
- **Inbreeding via the Peer Review System**: The peer review system used by the National Science Foundation, the National Endowment for the Humanities, and other patrons of education and educational software is extremely resistant to paradigm shifts and truly creative approaches. During periods of expanding funding this problem is less of a risk as there is funding enough for the established names in their fields, however, during periods of slow expansion or reductions, funds for "new entrants" and novelty become almost non-existent. Thus dependence on these systems to provide

for innovative advances in educational software can inherently thwart the intended goal.

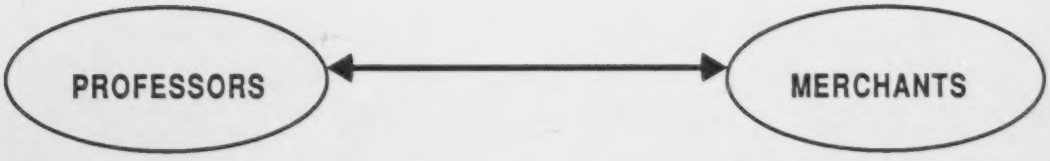
- **Inbreeding via the Cycling of People between Sources of Government Support and Supported Nonprofits such as Laboratories:** Scandura [1983] was very critical of the interaction between the National Institute of Education and the Regional Education Laboratories. He describes a cycling of people between these two groups that reduced expectations and reduced innovation. As NIE budgets shrunk, very little funding was available for educational research outside of the laboratories since the major commitment was to the labs.

  Long recognized as a hazard in government service, there have been laws passed that require government employees not to deal with their agency after joining the private sector.

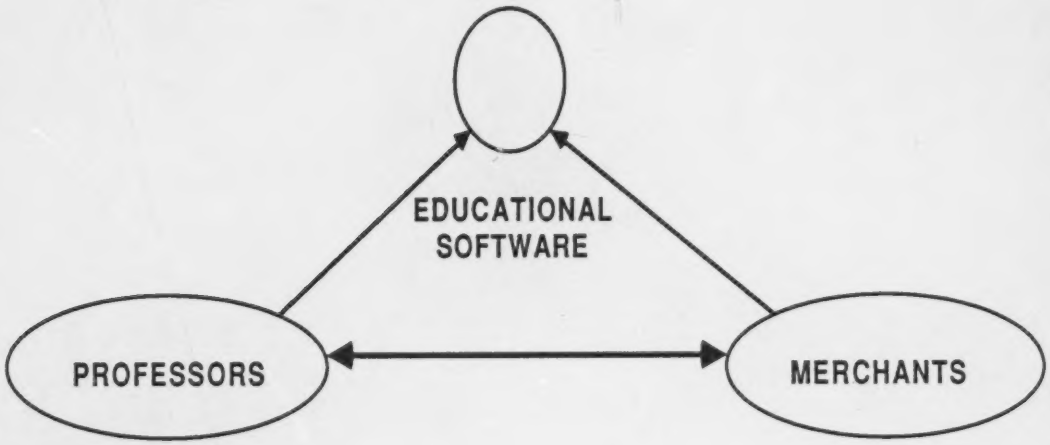
- **Capturing by Industry:** Particularly in the case of economically regulated industries, and partly as the result of the cycling of people described above, regulatory agencies have been *captured* by industry to one degree or another. For example, the Federal Trade Commission, primarily established to discourage unfair trade practices, has been in recent years captured not only by industry but by the federal executive branch.

GENERAL FRAMEWORK ON MARKETS, NONPROFITS, AND PATRONS

Returning to the first figure *Competitive Price System for Educational Software*, the relation between buyers who we will call *Professors* and sellers who we will call *Merchants* can be depicted as:



These two actors are expected to produce the social efficient level of software education as shown:



Unfortunately their output of educational software is not optimal, first because of nonprofit failure:

I. Nonprofit-Provider Failure

A. Limitation on Raising Capital
B. Lower Incentives for Managerial Efficiencies Due to Rigid Curricula (Risks to job security in being different)
C. Lower Incentives for Managerial Efficiencies Due to Lack of Competitive Pressure to Use Technological Innovations
D. Ignorance of Products
E. Ignorance of Outputs
F. Lack of Wisdom (Bounded Rationality) -- Inability to Judge Innovations
G. Lack of Voice (from Parents, Educators, and/or Patrons)

Secondly, the output is not optimal because of market failures — some apparent to the merchant and some not. Those apparent to the merchant are:

II. Market Failure (Apparent to Merchants)

2. Theft of Product (Piracy of Software) (inappropriability)
3. Theft of Innovation (inappropriability)
5. Commerce Discouraged (nondepletability) – must compete with past producers of educational products
9. Unapproachable (Uncertainty/Risk) – limits the willingness to take on large or lengthy projects
10. Ignorance (Search) –difficulty in buyers getting information about products
11. Poor Wisdom (bounded rationality) – difficulty in buyers assessing suitability of products
12. Underserved Needs (Information on Utility Functions) – difficulty for producers to learn about buyer preferences
14. Vulnerable to Theft (Information Transfers Good) – solving problems of search leads to problems of theft
16. School System Hindrance (Transaction Costs) – additional burden of contracts required with buyers
17. Duplication of Effort (Aggegate Overinvestment) – products are excessively duplicative or need for standards

And market failure that is not apparent to merchants:

III. Market Failure (Not Apparent to Merchants)

1. Tragedy of the Commons (Public goods) – there can be simultaneity of ownership and difficulty in exclusion
4. Donations Discouraged (Price discrimination) – inability to capture consumer surplus through tiered pricing
6. Low Veneration (Unsanctified) (Externalities) – benefits not captured in selling price
7. Wasteful (Indivisibilities of Supply) – marketing costs limit ability to sell small pieces as needed
9. Monopoly Priced (Economies of Scale) – monopolies raise prices above the level for economic efficiency
13. Unfair Trade Practice (Information Asymmetries) – firms withhold information, e.g., to hide lack of quality
15. Low Perceived Value (Unappreciation)(Intangibility) – benefits cannot be captured in dollar terms
18. Poor Legacy (Intergenerational Transfers) – benefits to future generations
19. Poor Equity – distribution of educational opportunity

The question now is why the Patron, as a third actor, is necessary? The answer is:

To Remedy:

I. Nonprofit-Provider Failure
II. Market Failure (Apparent to Merchants)
III. Market Failure (Not Apparent to Merchants)

The complete *Framework on Markets, Nonprofits, and Patrons* is finally shown altogether in one figure on the next page.

Finally, as described early, the patron is subject to patronage failure:

IV. Patronage Failure

i. Lack of Leadership/Vision
   a. Bounded Rationality
   b. Lack of Courage
   c. Political Constraints
   d. Political Boundaries (Locus of Educational Decisionmaking)

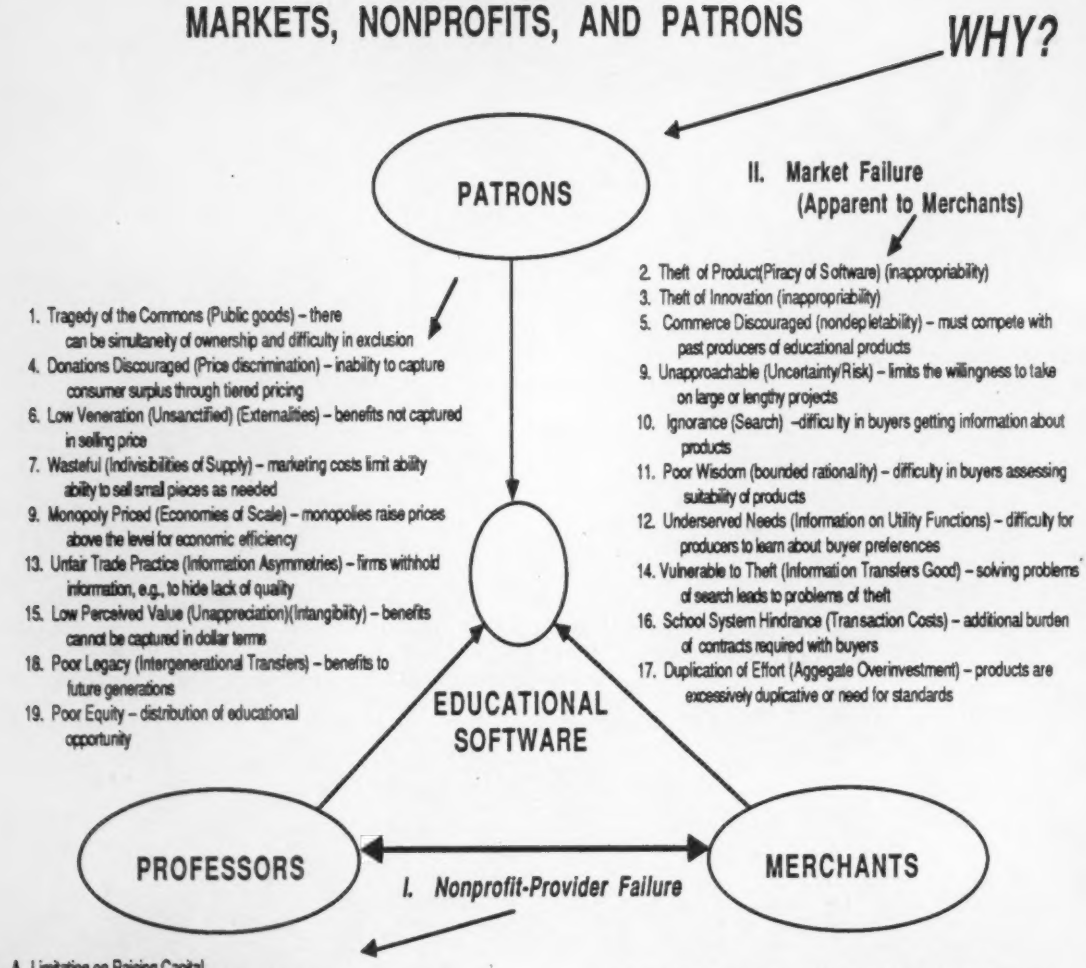
ii. Diversion to other Important Issues

iii. Degree Moral Issues are Affected

iv. Inbreeding
   a. Peer Review System – barrier to paradigm shifts and truly creative approaches
   b. Cycling of People between Sources of Support (e.g. govt.) and areas supported (e.g. laboratories)

v. Capturing by Industry – (particularly economically regulated industries)

FRAMEWORK ON MARKETS, NONPROFITS, AND PATRONS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MERCHANTS
I. Nonprofit-Provider Failure
A. Limitation on Raising Capital
B. Lower Incentives for Managerial Efficiencies Due to Rigid Curricula (Risks to job security in being different)
C. Lower Incentives for Managerial Efficiencies Due to Lack of Competitive Pressure to Use Technological Innovations
D. Ignorance of Products
E. Ignorance of Outputs
F. Lack of Wisdom (Bounded Rationality) – Inability to Judge Innovations
G. Lack of Voice (from Parents, Educators, and/or Patrons)

SOURCE: CENTER FOR INFORMATION TECHNOLOGY AND SOCIETY, 1987

The process is not entirely complete. At this point we have left the educational software unremedable when patrons fail to set things right. Fortunately there is yet another iteration of the nonprofit sector whose concern is the behavior of the patron as well as the professor and merchant. For the national concern on the environment this has included the National Resources Defense Fund and the Conservation Foundation. For technological innovation this included the MIT Center for Policy Alternatives. In educational software this includes the International Council for Computers and Education (Eugene, OR), the National School Boards Association's Institute for the Transfer of Technology to Education (Alexandria, VA), the American Association of School Administrators, the Center for Information Technology and Society (Lexington, MA), and many regional consortia such as the Educational Computer Consortium of Ohio (described in detail in Part II of this report).

Also, government has established a few entities to help overcome patronage failure. These include at the federal level the U.S. Congress' Office of Technology Assessment, the Congressional Budget Office, the U.S. Congress' Congressional Research Service, and the U.S. Government Accounting Office. Especially for education and educational technology at the state level these include the San Mateo County Office of Education in California and the New York State Department of Education's Center for Learning Technologies.

The role of these nonprofits is addressed further under Policy.

Market Failure in the Inputs to the Production of Educational Software

The general model presented above focussed on professors, merchants and patrons. There are also a number of other actors that play a role in the production of software. These are actors that supply inputs.

Two main categories of inputs are manpower and capital. In the case of educational software, the key manpower element is the author of educational software — the architect (in Young's taxonomy). In the case of capital there are two sources: the suppliers of technological hardware and the suppliers of financing.

Also, inputs are not singular but a chain of value added processes. Thus the supplier of the microcomputer (e.g. IBM) is dependent on the supplier of the microprocessor chip (e.g. Intel). The supplier of authored software is dependent on the supplier of authoring software (e.g. PILOT) and the supplier of authoring software is dependent on programming languages (e.g. C).

Policies related to inputs embrace increasingly wider areas of effect depending on where along the value added chain they impact. For example, government support of Very Large Scale

Integrated Circuits (VLSI) affect all innovations that embody semiconductor electronics. The support of standards activities for the C language would have a broader impact than support of standards activities for PILOT.

The banking industry is a critical component for the supply of financing. The success of Japanese industry has been partly attributed to the superiority of their banking system in better allocating capital for technological development. Equity markets and venture capital firms are also important. See for example Kelley [1971] *Venture Capital: A Guidebook for New Enterprises* and the General Electric study by Bendaniel [1974]: *A Study of Severed Venture Mechanism for Technological Innovation and its Broader Applicaton to American Industry.*

Contained in a University of Washington study by Woodworth and others [1970], is an in-depth coverage of: *The Entrepreneurial Process: The Roles of Accountants, Bankers and Lawyers.*

Another area of policy affecting the allocation of inputs has been tax policies especially the capital investment tax credit (repealed in 1986) and the R&D Investment tax credit (20% credit for R&D over previous levels). States have often affected the location of industry by negotiating special tax rates.

In terms of inputs there is a fine line between defining problems with inputs as market failure or as simply market constraints. For example, if there is a shortage of personnel, is this because there are just so many people to be employed or due to a misallocation of education in training them? In the case of hardware if there are not suitable graphics capabilities, is this because of the limits of the current technology or because of the misallocation (or absence) of funds for basic research?

In terms of education software, the Ten Firm Survey asked a number of questions related to the supply of inputs including availability of capital and financing, availability of personnel, and the role of hardware and software suppliers in the innovative process. Results of this survey appear in Part III of the report.

In summary, there are the following five, input side forms of market failure:

- **Availability of Capital** — The potential for underproduction of educational software due to the inavailability of investment capital
- **Availability of Financing** — The potential for underproduction of educational software due to the inavailability of financing (e.g. bridge loans for managing cash flow)
- **Availability of Suitable Personnel** — The potential for underproduction of educational software due to the inavailability of authors, editors, and other key personnel

- **Availability of Suitable Hardware Inputs** — The potential for underproduction of educational software due to the inavailability of adequate hardware
- **Availability of Suitable Software Inputs** — The potential for underproduction of educational software due to the inavailability of adequate authoring tools, programming languages, or programming tools

POLICY PRIORITIES

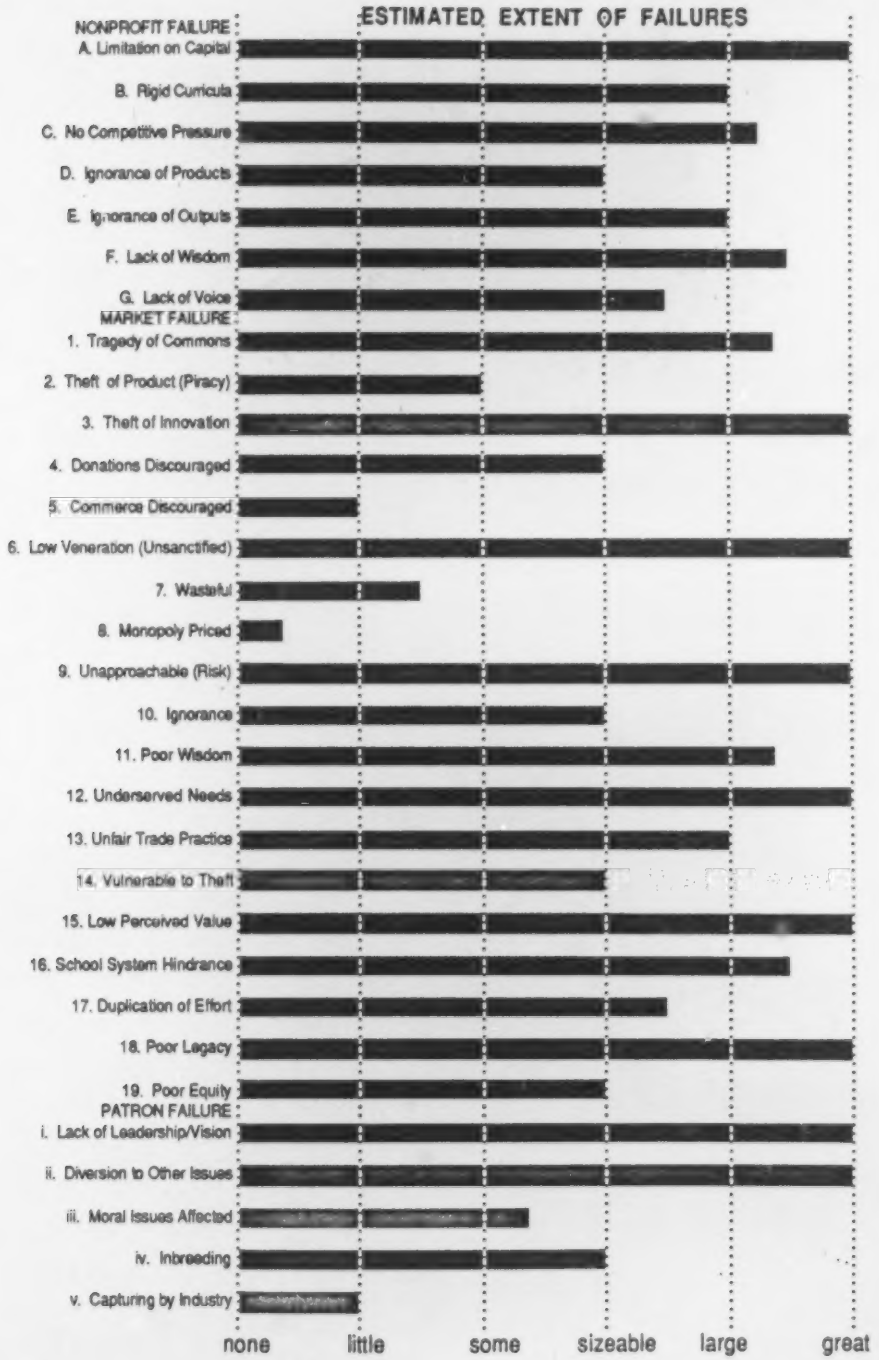
The establishment of policy priorities relate to two considerations. First, policies should be directed to the areas that exhibit the greatest levels of nonprofit, market, and patron failure. Second, priorities should be established where it is practical to reduce any of these failures. In policy analysis the first step is called identifying policy options and the second step is called feasibility analysis.

Based on reading over 420 pieces of literature on educational technology, innovation, adoption, and policy **and** the results of the case studies with firms and the study of information networks, the following table displays *Estimated Extent of Failures*. Twenty five of the thirty-one forms of failure are estimated to be at least *sizeable*, and seventeen are estimated to be *large* or *great*. Our policy options, therefore, should be chosen to remedy these failures in proportion to the extent that failures exist. Thus policy options for *capital availability* and improving *perceived value* are of greater interest than those directed toward *monopoly pricing* or *commerce discouraged.*

Before assessing the type and feasiblity of such options, we must turn to some history in the area of past successes that particularly pertain to the area of technological innovation.

Background on Policies for Technological Innovation

In 1979 the Solar Energy Research Institute (SERI) faced the question of what the role of government policy should be regarding the development of alternative energy. A study at the MIT Center for Policy Alternatives by Hill, Roesner, & Priest [1980] comprehensively reviewed activities of governments that affected technological innovation and empirical evidence of the consequences of technology-focussed policy instruments.


ESTIMATED EXTENT OF FAILURES
NONPROFIT FAILURE
A. Limitation on Capital
B. Rigid Curricula
C. No Competitive Pressure
D. Ignorance of Products
E. Ignorance of Outputs
F. Lack of Wisdom
G. Lack of Voice
MARKET FAILURE
1. Tragedy of Commons
2. Theft of Product (Piracy)
3. Theft of Innovation
4. Donations Discouraged
5. Commerce Discouraged
6. Low Veneration (Unsanctified)
7. Wasteful
8. Monopoly Priced
9. Unapproachable (Risk)
10. Ignorance
11. Poor Wisdom
12. Underserved Needs
13. Unfair Trade Practice
14. Vulnerable to Theft
15. Low Perceived Value
16. School System Hindrance
17. Duplication of Effort
18. Poor Legacy
19. Poor Equity
PATRON FAILURE
i. Lack of Leadership/Vision
ii. Diversion to Other Issues
iii. Moral Issues Affected
iv. Inbreeding
v. Capturing by Industry
none
little
some
sizeable
large
great

That study showed both significant successes and significant failures of government policy to remedy market failure. Among the findings were:

- Policy instruments available to government to overcome market failure include:
  - Δ Government procurement
  - Δ R&D funding
  - Δ Demonstration projects
  - Δ Financial incentives (grants, loans, tax preferences)
  - Δ Government performance and service delivery
  - Δ Product and process regulation
  - Δ Insurance, warranties, and certification
  - Δ Information delivery
  - Δ Education and training

- Reviewed the findings of the MIT Center for Policy Alternatives report to OTA [Hollomon, 1978] on the experiences of other countries in promoting innovation, and in particular noted:
  - Δ Most countries fund R&D in private firms
  - Δ Government purchasing - procurement policy, which reduces risk and uncertainty for the innovative firm, appears to be one of the most effective tools industrialized countries use to encourage innovation
  - Δ Provision of capital – most countries have programs to meet the capital needs of new ventures, either by venture capital corporations that buy equity shares in the firms or by direct government "start-up" funding available to firms introducing new technologies
  - Δ Industrial structure – to meet the requirements of rapid growth and international competition with technologically advanced firms, most developed countries force or encourage industrial restructuring through mergers, formation of public companies, elimination of technologically weak firms, and limited protection for emerging technologically oriented, weak firms
  - Δ Export Orientation – virtually all countries view technological progress as essential to capturing new export markets and meeting foreign competition
  - Δ Labor policies – most developed countries view the quality of manpower skills as their direct responsbility in strengthening the conditons for technological change

- o Empirical Evidence of Successes in Affecting Technological Change and Innovation
  - Δ Department of Defense procurements of semiconductors
  - Δ Federal support of mass transportation technologies
  - Δ Federal startup support of firms in providing energy conservation services
  - Δ Tax credits to encourage use of solar energy
  - Δ Tax free bonds for financing pollution control equipment
  - Δ Farm improvements through information provision via the Agricultural Extension Service
  - Δ Spinoffs from both defense and aerospace support
  - Δ Chemical regulation leading to new products and processes
  - Δ Fuel economy regulation leading to lower fuel consumption automobiles
  - Δ Building performance standards leading to lower energy consuming buildings
  - Δ Trade regulation to protect consumers
  - Δ Warranty policies to protect consumers
  - Δ Certification (licensing or registration) to improve quality and legitimacy
  - Δ Technology clearinghouse support for small minority owned businesses
  - Δ Support of nuclear power development
  - Δ Federal highway assistance program

Since the SERI study two important pieces of federal legislation were passed that have a strong bearing on technological innovation. In 1980 the Stevenson-Wydler Technology Innovation Act was passed. The passage of the act drew on President Carter's Domestic Policy Review which made the following nine recommendations for innovation [Schact, 1986]:

- o Enhancing the Transfer of Technical Information
- o Increasing Technical Knowledge
- o Improving the Patent System
- o Clarifying Antitrust Policy
- o Fostering the Development of Small Innovative Firms
- o Improving Federal Procurement
- o Improving the Nation's Regulatory System
- o Facilitating Labor/Management Adjustment to Innovation
- o Maintaining a Supportive Attitude toward Innovation

Stevenson-Wydler called for the creation of an Office of Industrial Technology to study and stimulate technological development. Further the Department of Commerce was mandated to establish Centers for Industrial Technology. These center were to be affiliated with universities or other nonprofit organizations to provide for cooperative research and development efforts between universities and industry and to develop a generic technology base for the Nation. The NSF was directed to support other Centers for Industrial Technology. A further requirement was to establish a National Industrial Technology Board to provide a forum for interaction and cooperation between the public and private sectors in the area of innovation. The Act called for better utilization of the results of federally funded R&D and called for the establishment of Offices of Research and Technology Applications within each agency to perform information dissemination and assist in the transfer of technology to the private sector. To aid the transfer, the Act directed the Department of Commerce to establish a Center for the Utilization of Federal Technology as a clearinghouse. Finally, the act called for the awarding of a National Technology Medal to individuals or companies for outstanding contributions to innovation.

Since enactment no funding was authorized for any of the Center activities called for under the act. The Department of Commerce (DOC) did establish the Office of Productivity, Technology and Innovation, and agencies with one or more laboratories made available not less the .5% of their R&D budget to support of technology transfer. The NSF does not operate Centers as called for under the Act but have funded Industry-University Cooperative Centers.

The main thrust of the the DOC has been to encourage innovation, not through government activity, but by removing institutional barriers to firms. The primary thrust has been to reduce the threat of antitrust under joint activities among firms with the passage of the National Cooperative Research Act and the encouragement of university-firm relationships.

Perhaps the most significant law regarding innovation was the Small Business Innovation Development Act of 1982. The law mandated that each Federal agency with an R&D budget of over $100 million establish and operate a Small Business Innovation Research (SBIR) program. The program is operted in three phases where both grant and contract supported is provided to small business in increasing amounts of support. Later funding is based on the success of earlier funding. A recent GAO study has shown that the law has been thoroughly implemented and recent SBIR hearings before the Senate Small Business Committee, the House Small Business Committee, and the House Committee on Science and Technology have indicated that most witnesses were pleased with the results of the Act. Through fiscal year 1985 of 26,000 proposals submitted, 3900 were funded for a total of $335 million.

Topics for funding in the U.S. Department of Education's 1987 SBIR program include:

- o Simplifying and Improving the Creation of Software
- o Improving the Usability of Software
- o Better Computer Technology to Simulate Job Settings of Handicapped Persons
- o Innovative Approaches to Bilingual Education
- o Application of Technology to the Teaching of Uncommonly Taught Modern Foreign Languages
- o Innovative Approaches to Instruction of Adult Learners

Policies Specifically for Educational Software and the Generation of Information in General

A major way government policy has supported the generation of educational software and information in general is by providing property rights to materials through copyright law. Ladd [1982], Assistant Librarian of Congress for Copyright Service has testified about the importance of copyright for the generation of new information and technologies. David Peyton [1981] provides extensive background on property rights statutes and also discussed the federal role in subsidizing information. He cites examples where federal support of software development have been important including the NASTRAN program by NASA to do structural analysis and Law Enforcement Assistance Administration supported software for local police departments. He cites the lead the U.S. has had over other countries in computers as a major result of Defense support of the industry. The federal government's support of public broadcasting has been instrumental in providing children's programming among others.

The most comprehensive review of the government's role in information technology for education is Chartrand's *Information Technology in Education: Perspectives and Potentials* [1980]. Prepared to support the subcommittee on Science, Research, and Technology, it extensively outlines all prior federal legislation and hearing activities in the field. Two other Congressional sources of review are the hearings for Albert Gore's National Educational Software Act [U.S. Congress, 1984] and a broad set of hearings on Computers and Education [U.S. Congress, 1983].

The mechanisms considered in these legislation proposals include the establishment of a National Computer Educational Software Corporation with the purposes of teacher training and software development through federal subsidy. A bill by Rep. Downey [U.S. Congress, 1983] calls for establishing National Centers for Personal Computers in Education. Such centers would

1) identify sources of courseware materials, 2) develop courseware materials, 3) develop curriculum materials to instruct students in the use of computers, 4) teacher training, 5) technology for handicapped, 6) demonstration programs, 7) software quality assessment, 8) monitoring of new technology developments, and 9) development of teacher training materials.

Other government support of educational software has included the NIE supported regional laboratories, the earlier activities of the Department of Education's Technology Resources Assessment and Development Division, and the National Science Foundation particularly in the area of science curriculum [See further comments in Part IV of this report by IBM and McGraw-Hill about this program]. At the state level there is considerable activity but most notably the California support of software development by firms out of Wendy Harris' office in the Department of Education [See further the comments by one of the Ten Firms, "Major Force" in Part III of this report and also the comments about Governor Brown and Steve Jobs in the interviews with "Early Out."]

An excellent reference on *Subsidies to Innovation in Instructional Materials* appears in Goldstein[1979]. Some of the activities outlined include: NDEA Title III, ESEA Title II, NDEA Title VII, NIE, the Regional Laboratories, ARPA support of CAI, the Robert Wood Johnson Foundation on teaching materials, George Gund Foundation for social science curriculum materials, the Babcock Foundation's support of EPIE, the Exxon Education Foundation's support of CAI for remedial English, and the Moody Foundation support for videotaped curriculum. Further activities include: Carnegie Corporation's support of the Children's Television Workshop (Sesame Street and Electric Company) along with the Clark Foundation and the John and Mary Markle Foundation, NSF's support of the Physical Science Study Committee at MIT, their support of Minnesota School Mathematics and Science Teach Project, and Man: A Course of Study.

Selected references on innovation, the promotion of innovation, and government roles are presented in Part V of this report.

FUTURE FEDERAL POLICY FOR EDUCATIONAL SOFTWARE

Introduction

Federal legislative attempts have been largely unsuccessful because of the climate within the last decade to reduce federal involvement in education and business. Letters from Keyworth's office and others, attached to the hearings, were always condemning of the legislation for these reasons.

However, even in a climate more conducive to a stronger government role, direct federal involvement in education is likely to be still restricted by a strong political preference for local and state authority. This situation has strong implications for the feasibility of federal policy options. In particular, it suggests that federal policy is best oriented at **indirectly** supporting state and local activities much in the way that ESEA provides for title funds to the states and localities. Indeed, the title funds have been the most instrumental way the federal government has affected the development of educational software to date. [In the survey of information networks, Part II of this report, title funds were often cited as important in obtaining software and equipment. Also, regional service centers and state level computer consortia were important resources, as was EPIE and some other information clearinghouses. However, in over 100 discussions, except for Northwest Regional Laboratory's evaluation products from MicroSift, no regional laboratory was ever mentioned as a source of support or information.]

Based on the these considerations, efforts for the federal government to *directly* establish training centers or software development firms such as have been the substance of the bills discussed above are highly unlikely to succeed in the best of conditions. In contrast, government support of independent nonprofits that have naturally arisen to met these needs is much more likely to be feasible and successful. A "two-step" approach is suggested but in a different way than was envisioned with the formation of the NIE regional laboratories. The problem with that model of policy was the regional laboratories viewed their client and constituency to be Washington, not American schools. In contrast, the many consortia that are being formed within states are responding directly to the needs for teacher training, software evaluation, etc.

With this general strategy in mind and the history of policy for innovation as a perspective, let us turn back to the specifically identified forms of market failure and identify some policy options for further consideration.

Policy Options and Their Feasibility

As suggested above, we will consider policy options that address market failures that are extimated to be at least *sizeable* (see figure above, *Estimated Extent of Failures*).

Limitation on Capital

Both Moursund [1984] and Levin [1985] agree that the lack of capital at the local level is one of the greatest problems for educational software (and hardware). Moursund's suggestion is to adopt a permanent commitment to allocating 2 % of a district's budget for the instructional use of computers. This would lead to one microcomputer per 10 students and adquate software, inservice education, coordinators, and contingency funds. Levin proposes a software development fund. This would involve a revolving loan fund in which loans were repaid out of royalties from sales of software created under financing from the fund.

Regarding Levin's proposal, it is true that revolving funds have been useful particularly in developing countries where financing is scarce and the labor rates are low enough to guarantee increasing world trade. Such a fund was recommended by the MIT Center for Policy Alternatives for the KDTU of Korea — their industrial development organization, and was successfully adopted. After several years earlier projects are paying for later ones.

Levin's proposal, however, does not solve the basic problem that Moursund's suggestion attacks — the lack of financial commitment to purchase the software (and hardware). A revolving fund is not much use if there is still not sufficient demand to repay the fund.

Moursund's proposal has both an advantage and a problem with being a fixed level of funds. The advantage is that it represents a high level of steady commitment by schools and therefore would encourage software development and development of even higher risk projects. The disadvantage is it may push schools into acquiring unneeded or unnecessary software and equipment just to meet the goal. Numerous respondents both within schools and within firms commented in the interviews (Part II,III) that end of the year money from Title II and other sources that had to be spent or lost caused a last minute wave of buying, not necessarily very thoughtful buying. Pogrow [1983] has recognized the problems with school budgets and suggests that it be permitted to allow school systems to carry surpluses into future years. Current practice discourages this according to Pogrow because taxpayers would be upset to see school districts bank money and would feel school tax rates were too high. In addition, Pogrow's suggestions for accounting and budgetary procedure reforms include 1) promoting greater equity in capital outlay expenditures on a statewide basis, 2) allowing districts to charge for depreciation costs, and

3) allowing, or providing incentives for, districts to use a percentage of general operations for capital outlay purposes (parallel to Moursund's suggestion).

Perhaps the closest funding parallel to historical support for capital outlays are the federal experiences with mass transit and the Federal highway program. Like schooling, these were funds provided from federal taxes but distributed for local development. In both instances, the positive externalities of both activities was seen to warrant a federal role. In some of these programs, the federal government would use matching funds sometimes on a 80% federal and 20% local to guarantee that the development was actually needed.

Action at the federal level would also have an advantage of providing immediate strength to the market, in contrast to each district or state adopting some sort of subsidy or budget allocation program. Currently the activities at the state level that come closest to this goal are modest levels of funds as line items in state legislation or the commiting of lottery funds to software and hardware.

Policy Option Recommendation Regarding *Capital Limitations.* As a first option, the federal government should consider a Software Development Fund that is matched at the local level and is designed after the Federal highway program. As a second option, the federal government should consider expanding ESEA Title II funds for this purpose and at a sufficient magnitude to at least meet Moursund's suggestion of a 2% level. As a third option, the federal government should provide seed monies to accelerate state and local adoption of budget targets. These seed monies might go to state and local levels directly, or through nonprofits whose goals are to accelerate the adoption of higher budget levels.

Rigid Curricula

Curricula, unlike funds, are very much a matter of local control and decision-making. Thus while the National Science Foundation and Departments of Education should continue to invest in basic research leading to possible improvements in curricula, it is improbable that the federal government should make any direct attempts to influence school curriculum.

Nonetheless, there are numerous nonprofit organizations including the National Education Association (NEA), The American Association of School Administrators (AASA), The Association for Supervision and Curriculum Development (ASCD), and numerous professional associations for teachers in each field of study — math, science, social studies, etc. The aim should be to promote the sort of teacher/administrator *professionalism* that is commited to evolving curricula with the possibilities of computers and educational software. There already is a strong sense among all these organizations to perform this function. However, like all nonprofits, their support base is capital limited to membership fees and donations. The National School Boards Association's

Institute for the Transfer of Technology to Education has about $5000 a year they can use for outside consulting to help achieve their goals to transfer technology to education. This is a tiny amount and hardly enough to attract talented people to aid their efforts.

Policy Option Recommendations Regarding *Rigid Curricula.* The federal government should identify and work with all *change agents* , especially at the local and regional (within state) level, for improving curricula. A budget of say $500,000 per state would go a considerable distance in accelerating the process of curricula change and compatibility with educational software. The federal government could use survey methods such as that incorporated in Part II of this study to investigate how effectively each change agent was using the funds and target further funding accordingly.

No Competitive Pressure

As described above, voice, for the efficient guidance for nonprofits, is the parallel to price signals for business markets. Correspondingly, *professionalism* in teaching and school administration is the parallel to competitive pressure for technological change in the business sector. In Part II of this report the adoption process is described and the role of early adopters is highlighted as important leaders for others to adopt innovations. An important role of professional societies and organizations is to ensure that early adopters are present and able to influence other adoptors of the technology.

One way of achieving this goal is to target professional associations as leveraging points for building up key staff and resources. Another is to identify professional associations that are themselves too antiquated and provide startup funds for ones that better serve the professional community with regard to technology leadership. In addition, there are nonprofit associations that generally promote instruction and computers that can expand their memberships into the school professions. These associations include ADCIS (Association for the Development of Computer-based Instructional Systems), ASTD (American Society for Training and Development), NSPI (National Society for Programmed Instruction), AECT (Association for Educational Communications and Technology, and SALT (The Society for Applied Learning Technology).

Policy Option Recommendations Regarding *No Competitive Pressure.* One option for the federal government is to subsidize memberships of teachers and administrators to nonprofit associations which have a significant role in establishing *professionalism* in the use of educational technology. A further option is fund a staff member of these organizations whose role is to provide a "gatekeeper" function in stimulating adoption of technology in the schools (see the discussion in Part II of this report). One way to maintain touch with the schools is to require that

this person be on loan from a school and receive any further training needed to hold the position. This could even include tuition and stipend allowances for graduate studies. [Note: NDEA was very instrumental in funding the training of many scientists and engineers by providing grants to universities for tuition and stipends.]

Ignorance of Products

Part II of this report identified two channels by which teachers and administrators become aware of educational software products. Teachers largely depend on the magazines and journals in computers and education. Administrators largely rely on information networks with regional service districts, consortia, and state contacts. Further there is considerable interaction between teachers and administrators.

Teachers who are involved with computers range from fairly informed to very informed about educational software products. This group has been estimated to be less than 20% of the teachers. The other 80% or more percent are very ignorant of educational software products.

One highly practiced way of introducing more teachers to the technology is inservice training. This has seen clear successes and guides such as Shirley Boes Neill's *High Tech for Schools* [1984] places a strong emphasis on training in the innovation adoption process.

One of the roles of the nonprofit computer and education consortia that have sprung up in many states is to provide inservice training. For example, the Merrimac Valley Educational Consortium in Massachusetts has made arrangements for onsite training that also provides degree credits with Fitchburg College. Other consortia such as one in Vermont has brought two week training sessions to the schools to help teachers avoid travel time and costs in a rural area.

These examples illustrate again the importance of a locally oriented nonprofit organization in aiding the inservice training process (whether a consortium or a local college). Thus from a federal perspective it again makes sense to work with these training organizations in supporting their efforts. Discussions with a number of them have indicated the extreme budget limitations in developing staff or services. Yet it is these groups that have the interest and loyalty to provide or assist inservice training of reasonable quality.

Policy Option Recommendations Regarding *Product Ignorance*. The federal government should provide subsidies to nonprofit organizations such as consortia or colleges specifically earmarked to increase teacher inservice training. The federal government should also consider defraying the costs to the school system, for example, by a subsidy to pay for substitute teachers while the teacher receiving training is away. The federal government should also consider seed monies for local colleges to establish or expand their school of education curriculum to better

provide inservice training. [See Part IV, discussion with IBM, about their support of inservice training curriculum materials for using computers in teaching reading. The only problem with privately supplied materials such as these is they are likely to promote "Write-to-read" — IBM's own product in the area of reading software.]

Ignorance of Outputs

Most of the outputs of education are intangible. Those that can be measured such as specific skills in math, science, and reading are of limited value in assessing the overall quality of education delivery. Teachers and schools will have great difficulty in assessing the educational achievement — outputs, when educational software is introduced. The consequence of this includes misapplication of the technology, underutilization, and overutilization.

Already there is a large body of research literature about measurable effects of educational technology. In fact some commentators have commented that if the entire process of education were subject to the same scrutiney that has been applied to educational technology, we would be mired in studies.

Nonetheless, there certainly is useful information that can be provided schools about the effect of educational technology on the quality of their education. These types of information could be more clearly identified and more standard means to provide this information could be established.

Policy Option Recommendations Regarding *Ignorance of Outputs*. The federal government should fund research in identifying practical, useable measures of the impact of educational technology on the quality of education. Further, the federal government should provide schools with materials or facilities that aids schools in assessing the effects of educational technology within their own community. Finally, the federal government should identify information about outputs that are universally of interest and make this information easily available to editors of computer magazines, etc. Just as the Federal government has an important role in census data, etc., the government could provide information and data about the effects of educational technology that is of general interest. One model to imitate is the *Science Indicators* report of the National Science Foundation. Henry Becker's project at Johns Hopkins University is also an excellent step in this direction. This suggests that as an alternative to government provided information, the government could more substantially fund efforts such as Becker's.

Lack of Wisdom

Remedies to *lack of wisdom* include education and leadership. Thus some of the inservice training teachers receive will not only remedy *ignorance of product* but also *lack of wisdom*. There

are many levels of wisdom, however, that enable a teacher or administrator to grasp the applicability and need for educational software. Development of computer literacy is only one sense that these people require.

Other levels of wisdom go to appreciation of the value of the contribution of educational technology to learning and the values to society. These topics are discussed below under *low veneration* and *low perceived value.*

One component of wisdom is to recognize and respond to intellectual leadership. For example, in a recent workshop at an Ohio Educational Consortium on Logo, Seymour Papert was brought in as a key speaker. His presence and enthusiasm did more for the audience than the specific things he said about turtle geometry. Unfortunately, Seymour Papert is extremely busy and extremely pressed by many to provide his leadership, and he cannot physically meet the entire country's need for intellectual leadership by himself.

Alan Kay who is the key person behind the Vivarium project in California is another intellectual leader who instills excitement and interest. Unfortunately the circle of these people is very small, Alan spending time with Seymour at MIT, and meanwhile the rest of society must wait for the occasional interview that appears in a popular magazine, e.g., *Electronic Learning* [Papert, 1986] or an appearance by Mary Alice White.

But *should* we be able to count the number of visible intellectual leaders for exciting new uses of computers, microworlds, and vivariums on one hand. Are there many invisible intellectual leaders or are there really only these few? [Note: educational computer leaders such as Ludwig Braun, Alfred Bork, David Moursund, Gregory Benson, Marc Tucker, and Stanley Pogrow are discussed later under *Lack of Leadership/Vision.*]

The review of over 420 pieces of literature for this report suggests that, indeed, if there are more out there, they are very quiet about it. There are many enthusiastic people, for example, at Lesley College and their annual Education and Computer conference but last year they tapped Gregory Benson to be the keynote speaker, again only one of a few identifiable figures.

The lack of intellectual leadership is most likely due to the impoverished state of federal funding for creative projects in educational software and for computer "environments" in general. It is difficult to believe that if there were not more opportunities for intellectual leaders to arise there would be many more of them. Yet these leaders are the only source of concrete inspiration that teachers and administrators can look to. This suggests that a major reason for increased federal support of R&D for educational software is not necessarily for the specific products that the participants will produce but for the leadership that these activities will build.

Policy Option Recommendations Regarding *Lack of Wisdom*. Federal support of R&D for educational software should probably increase by one or two orders of magnitude to build up a cadre of intellectual leaders who can instill enthusiasm in teachers and administrators. Such projects should be chosen not solely to advance basic knowledge but rather to encourage innovative, idea generating enclaves. This suggests that traditional peer review mechanisms such as used by the National Science Foundation may be highly unsuited to this task since peer review tends to 1) over-emphasize rigor and academic knowledge, and 2) favor established traditional academics in traditionally recognized settings. [See further the discussion on patron failure — *inbreeding*.]

Lack of Voice

The literature cites numerous instances where parents have been a propelling force for having computers in schools. For example, PTA bake sales have been used to help procure equipment. Nontheless, in the discussions with teachers and administrators (Part II of this report) neither students nor parents were cited as sources of information or impetus. This implies that the average level of voice from parents provided directly to the school system is relatively low. School boards (an indirect mechanism), however, were cited as actively involved in computer education decisions and this is the primary form of community voice.

Community action and citizen participation is a broad field involving the ways grassroots support builds for political support and change. Studies by the Kettering Foundation in the 1970's found evidence that like any information network, there were those citizens who were openly active in the community and they were estimated to be about 2% of the general population. These were the people who were members of school boards, PTA's, or spokespeople in public assembly, etc.

For support of budget changes in the schools (which is perhaps the most critical form of market failure today), it is this 2% active citizenry that will have the primary responsibility for change. Thus overcoming inertia in this system involves information and influence. Ewald [1975] describes the process of regional decision making and, in particular, describes programs designed to improve information access and regional policy. Issues of education and energy were part of a field study in the Santa Barbara County of California. The study shows the steps of building constituency including the role of studies, videocassette presentations, advisory boards, public television, and other communication channels.

One model for constituency building has been considered by the Florida State Department of Education, Commissioner's Task Force on Instructional Computing [1986]. A proposed network involving school districts, community colleges, and others is described and a total appropriation of

$44 million is suggested to implement it.

Policy Option Recommendations Regarding *Lack of Voice*. The federal government can aid this process without intruding in it. This can be accomplished by 1) subsidizing the production of information materials useful to mobilizing local support, 2) providing seed monies to nonprofit organizations that would actively work with localities to improve the process, and 3) underwriting the costs associated with public television, local cable, and other communications media. In this way, decision making is left to the localities who can choose to work with nonprofits or not, and can choose to use information materials that they find most suitable to their own needs. Often, materials developed by a local group is an excellent source of materials that can be made available elsewhere.

Tragedy of the Commons

Levin [1987] describes the most important public good aspect of education in the way it "improves the lives of the children and their families who participate." In particular, "[s]chools provide students with a common set of values and knowledge to create citizens who can function democratically" [p. 630].

Thus, society left to the private market would incur the *tragedy of the commons* by neglecting to invest in these learning needs and concentrating only on those vocational needs of industry. Government has a continuing interest in supporting and operating schools for this reason.

The greatest tendency in a world of changing educational technology will be the rise of private sector educational alternatives which would threaten the provision of the public goods of education. In the extreme we might imagine stores like video cassette rental shops that rent out "all you need to know to succeed [in business]" educational software. Many states permit "home schooling" of children given evidence that the child will be accorded a strong learning environment. Thus parents could opt out of public schools with greater ease and public good aspects of education would decline.

Policy Option Recommendations Regarding *Tragedy of the Commons*. The role of government, as it has in the past, is to mandate certain schooling requirements. These mandates have been the provence of states and taken the form of "compulsory education." Since the extent of educational technology is so minimal today, there is no current presence or awareness of the threats to the public good aspects of education. But it is not too early to establish a program to monitor the effects and incorporate the results as part of one of the reports to the President. Unfortunately, there is not a ready haven for such an activity within the federal government (e.g.

like a CEQ, the Council on Environmental Quality). As an alternative, the federal government could establish an independent advisory board (perhaps fashioned after NACOSH, the national advisory board for OSHA). The members could receive a stipend and national recognition for their contributions.

Theft of Innovation

Both patent and copyright protection represents this country's recognition of providing property rights for intellectual property so to protect property and encourage its development. While *theft of product* is a somewhat sizeable deterent to private production of education software, theft of innovation is a great deterent. As described before, Broderbund's success in the courts to have the "look and feel" of a software program covered under copyright is an important step in protecting firms' innovations.

The major problem with patent protection is that systems that include the human person may not be patented. Since educational software innovations include by their very nature the human person, there is a major gap in patent protection for innovations in the field. And aside from the Broderbund case, copyright protects only the specific text or code used to produce the educational software effect. Thus, an imitator need only rewrite text and rewrite code to achieve the same effect and there is no legal protection against this activity. Indeed, in the business sector where profits and volumes are larger, there have been successful imitations of Lotus 1-2-3, dBase II, and numerous other successful products.

The only recent government success in improving protection of property rights was the passage of a new form of protection for semiconductor integrated circuits — the mask right. This placed the mask designs for the fabrication of these circuits under protection, reducing the ease with which East Asia could imitate and undersell American production of semiconductors.

There is the classic problem of the conflict between the providing of property rights to encourage innovation and the resulting lack of availability of those innovations for others to base their innovations on. For example, in fields where large advances have been subject to patent such as xerography and instant photography, other firms were virtually excluded from the market until those patents expired. For example Kodak's exit from instant photography resulted from Polaroid's successful patent infringement suit. In most markets, however, patent licenses are available and reduce the inavailability to other firms.

In education software innovations there is a similar conflict. If a unique combination of knowledge database, modelling, and video display were subject to patent this would have two effects 1) firms would be much more aggressive about being first to develop such a system, and

2) other firms would have less access to this as a development tool. Nonetheless, on the whole we have been pleased with the results of patent protection and its positive effects on innovation and one would have to trust that such protection in this field would have similar powerful effects.

One of the problems with building support for further property protection of software relates to one inherent advantage the software producer has over the hardware manufacturer. Once development investments are made, the costs of reproducing (manufacturing) the product is extremely small. This situation greatly reduces the pressure on software producers to push for property protection. Nonetheless, from an economic efficiency standpoint this may not be optimal. The lower manufacturing costs are in effect a "cross-subsidy" to the losses in economic efficiency due to lack of better property protection. That is, the fact that the industry has not pushed harder for greater protection is not necessarily a correct signal that such protection is not needed (economically efficient). Software industry associations such as ADAPSO and SPA have focussed mainly on *theft of product* not *theft of innovation.*

Policy Option Recommendations Regarding *Theft of Innovation*. The federal government should devote extensive study to the question of the need for greater property protection for educational software. These studies can continue the substantial work performed by OTA last year. To quote their study, "if Congress is to devise a sound intellectual property policy for the future, it must begin now to establish a mechanism to collect and evaluate information about how the system works and where it may be heading." In response to further study, Congress should introduce bills and conduct hearings to better ascertain the extent of the problem.

Donations Discouraged

Public schools are quasi nonprofit institutions. They are directly funded by local government and states but manifest most of the properties of an independent nonprofit institution. However, their direct attachment to local government discourages donations by parents who value public education above what they pay for it in local taxes.

This is not a new problem but it is one that many people in policy are newly aware of. The problem also applies equally to all public education not just to educational software. As mentioned above, there are occasional opportunities for donations through the parent-teacher assocations, where members volunteer their time and funds have been raised for computer equipment.

State funds are an indirect form of donation, taking funds from state taxes and providing them to local schools. Curiously, the majority of funds for elementary and secondary schools come from the states (38.5% state, 25.8% local, 6.5% federal, and 10.5% all other, *Statistical Abstract of the United States, 1987*). Nonetheless, this is not a true form of donation but a

government subsidy.

During periods where school enrollments were shrinking, there were too many teachers, and localities were concerned about levels of taxation, the climate for further funding (donations or otherwise) was quite poor. Recently, budgets have been less stringent except for Texas where the lack of oil monies have hampered all budgets. During this developing period of educational software, schools in the computers, and a growing enthusiasm about the implications for school curricula, there will be a substantial number of parents willing to make donations, particularly if those donations are earmarked.

Policy Option Recommendations Regarding *Donations Discouraged*. This suggests that schools may want to consider specific ways of encouraging donations such as by placing educational software activities in a separate nonprofit organization, as a "service center" for the school. The federal government could encourage the formation of these bodies by providing funds to subsidize their operations and, thereby, encourage their formation. Just as government policy to withhold federal monies to enforce the speed limit has been an effective way of getting coordinated state action, so would the provision of funds for the formation of *School Service Centers*.

Low Veneration (Unsanctified)

We venerate books, especially classics. We venerate education and the teaching profession. But do we venerate educational software? No, primarily because it is too new and veneration is a process that takes time. There is also the question whether educational software deserves to be venerated.

Yet there is growing evidence of the positive effect one-on-one teaching with computers has on student learning. And, there is increasing awareness of the opportunities to marry whole information databases (and knowledge databases) with the process of education via the computer unlike ever manageable before. H.G. Wells, prophet and political scientist, wrote *World Brain* in 1938, some twenty years before the first computer. Nonetheless, he pictured, as Diderot had before him, a society that was so fully informed that the benefits penetrated throughout society. These positive externalities to education are enormous. Education empowers the individual to accomplish and to be at peace with the world. There is every likelihood that educational software is the beginning of an embodiment of knowledge and wisdom unlike society has ever witnessed.

Nonetheless, there are those in society who focus on negative externalities from technology, the creation of assembly line work or the production of smog and pollution. Can a society with these experiences embrace information technology that has such inherently positive effects? Or will

suspicion of centralized control or loss of privacy still dominate the debates over computer information systems. And, further, there are those intellectual leaders who were too early and turned sour as the limitations of the technology thwarted their dreams. Writers such as Oettinger, Weizenbaum, and Bok have cast dispersions on the field and it has taken writers such as Sherry Turkle (previously married to Papert) to provide a renewed sense of the value of the computer.

Only vision and leadership will provide impetus to growth of veneration for educational software. This vision and leadership will come from four sources 1) the intellectual leaders (described above), 2) educational computer advocates, 3) political leaders, and 4) the media. These are not a disparate group of forces but entwined. The process by which movements in society have progressed has been well documented in a review of the social forces leading to social legislation in *Risks, Concerns, and Social Legislation* by Priest [Westview Press, 1987].

Federal government has provided some forum for these people. The Congressional hearings, especially those held by Albert Gore [1983] have provided a platform for advocates and political leaders to speak positively and broadly of the promises of new educational technology. Unfortunately, the associated bills were poorly conceived and could not muster political support.

The most important role of federal government in the early stages of this process is to ensure adequate funding to activities associated with key intellectual and advocacy leaders. To do this takes political leadership and this subject is addressed under *Leadership/Vison* below.

Policy Option Recommendations Regarding *Low Veneration*. Federal government must provide needed seed monies to ensure that intellectual leaders and advocates can aid the movement toward encouraging veneration of educational technology and information technologies in general. The major way this can be accomplished is to have the federal government support research and development that **shows the connection** between the capabilities of the new technology and their ability to solve problems of society, educational and otherwise. (see report introduction).

Unapproachable (Risk)

Problems of risk are often solved by an investment portfolio (as described in the market failure discussion). Unfortunately there is a bind. Small firms are the sources of more creative innovations and small firms are least likely to be able to diversify risk since their portfolio is too small. The recent attempt by California to fund software projects, and in particular, more costly ones was one approach to solving the problem of risk.

Levin's suggestion [1985] for a software development pool of funds is another means of risk spreading where successful projects help pay for unsucessful ones and where the funding

ultimately comes from the market rather than through taxation. The success of such risk spreading pools have been demonstrated from the experiences of other countries [Rao, 1981].

Another means of risk spreading is for smaller firms to make arrangements with larger firms to provide risk capital in return for returns. Also, the equity/venture capital market is a principal means for risk spreading but only if there are likely to be sizeable profits to offset potential losses.

Another suggestion by Levin [1985] is co-development with a school system or district. The sharing of costs reduces the magnitude of the project to the small firm and working with a school district reduces the uncertainty about the product's marketability. [Indeed, one of the firms interviewed in Part III indicated they welcomed a co-development arrangement.]

The primary source of uncertainty and risk, however, relates back to the school system again. For example, it was cited by the firm "Early Burned" (see Part III) that McGraw-Hill's million dollar math series software effort was not adopted by the State of California. Thus, state adoption policies serve to increase risk and uncertainty and discourage innovation. Nonetheless, Texas is actively looking into state adoption policies for educational software.

Perhaps the greatest way to reduce risk and uncertainty, therefore, is to build up the demand side (not the supply side). Levin's suggestion of a development pool makes sense if some successful large projects will pay for the unsuccessful ones. But if schools are uniformly unable to provide a market demand for larger projects, then no amount of risk spreading will solve the problem. Strength on the demand side would also strengthen the venture capital/equity market and supply of risk capital.

Policy Option Recommendations Regarding *Unapproachable (Risk)*. It is suggested that government **not** devote extensive resources to reducing or spreading risks at least until the demand side is stronger. This position should be reevaluated as the market changes.

Ignorance

Ignorance on the part of buyers is covered above under *Nonprofit failure: Ignorance of Products.*

Poor Wisdom

Poor wisdom on the part of buyers is covered above under *Nonprofit failure: Lack of Wisdom.*

Underserved Needs

This problem of market failure addresses the difficulty for firms to match the capability of the technology with the actual needs in education. Since the process of education is complex and involves both imparting values as well as knowledge, the current line of drill & practice and tutorial

products is quite elementary and rudimentary. Further, the architects who have both a strong sense for education and can get the computer to provide something significant are very few. [See Part III of this report regarding availability of personnel.]

To a large extent educating is an art, not a science. Therefore, it is not easy to rush into promoting a science of education that enables architects to better integrate computers and education. Throughout the literature, however, are calls by those in the cognitive sciences for greater attention to research in the field for the design of products.

Nonetheless, of any area amenable to basic research is the interface between "man, society, and machine." While ergonomics and human factors are two basic considerations, these do not get at the relation between components of human behavior such as beliefs, attitudes and values. One of the most important contributions in this field has been Russell Ackoff's *Choice, Communication, and Conflict* (published as *On Purposeful Systems* [1972]. In this work is contained a framework for understanding the purposes of information, knowledge, understanding, and in relation to attitudes and values.

Unfortunately, traditional areas of cognitive sciences, educational theories, and psychology have not kept pace with the progress in behavioral science as Ackoff and others have pioneered. Research in computers and intelligence has become bogged down for years in problems of language and semantics. And while these problems are important in the long run for the development of computers capable of listening and talking, they are not central to understanding the role of information and knowledge in aiding individiuals in accomplishing life's tasks.

Policy Option Recommendations Regarding *Underserved Needs*. The federal government, and the National Science Foundation in particular, must fundamentally reassess their support of basic research relevant to the advances of educational software. Current peer review practices and program agenda have produced little of value to the field. Programs such as Ethics and Values in Science and Technology(EVIST) spend too much of their funding on problems of ethical violations and concerns about professionalism in science and technology and not enough funds on how information technology can be of assistance with concerns for ethics and values. The recent EVIST supported project *Alternative Designs for Medical Information Systems -- Consequences for Health and Human Values* [Priest, 1986] was very difficult to get funding for and represents the only project under the program of its type. One of the greatest hurdles was trying to avoid the contention at NSF that health and medicine were the province of HHS, not NSF. Attempts to get funding of research to extend Ackoff's work in the area of modelling was unsuccessful in the NSF branch of decision sciences, again because of a peer review system too

wed to traditional notions.

Unfair Trade Practices

There is a general expression in the literature that there is a lot of junk in the educational software market. Since buyers are unsophisticated it is difficult for them to distinguish a math program that is of high quality from something of little value.

Further, it is not in the interest of sellers to inform buyers of the quality of their products and those with products of inferior quality will keep this information from the buyer.

The major remedy for this has been the independent establishment of software review nonprofit institutions. The Educational Products Information Exchange Institute (EPIE) is a key example of such a nonprofit filling this role. The National Education Association has also performs this role (and been criticized by the industry association for its practices [Software Publishers Association, 1985]).

Policy Option Recommendations Regarding *Unfair Trade Practice*. Nonprofits have arisen to provide a consumer protection role in the market. The federal government should more closely ascertain the ability of these groups to perform credibly given their revenue base. If revenues are weak, the federal government may wish to do revenue matching to subsidize these groups.

Vulnerable to Theft

Increasingly to overcome problems of search (*Ignorance*) firms are providing preview copies to schools for evaluation purposes. These copies are almost always copy protected but commonly available software and hardware can enable schools to make copies anyway.

The problem addressed here (in contrast to the problem of *theft* per se, earlier) is the reluctance of firms to provide information about their products to reduce piracy. This reluctance increases the problem of ignorance which is one of the most important problems to overcome.

Schools have increasingly paid attention to the problem of piracy and many have issued strict guidelines to teachers to prevent copying. Mouresund [in Neill, 1984] provides a model *District Policy on Software Copyright* that the International Council for Computers in Education encourages districts to adopt.

For the meantime, the problem has been abated by the combination of school policies and copy protection on diskettes. However, as we enter an era of networked computers and increasing presence of hard drives on microcomputers, firms will be forced to remove copy protection so these systems can load the software. Thus we may in in a lull before another period of strong concern.

Policy Option Recommendations Regarding *Vulnerable to Theft*. Perhaps the only role that government can play is that of enforcer. Prosecution of severe violations will serve as a deterent to others.

Low Perceived Value

Is $49.95 a lot or a little for a software package? When compared against the cost of a blank disk (39 cents) it sounds like too much money. But what about it compared with the value of the learning that takes place as the result of it. This problem of intangibility or the non-monetizability of the good is a severe problem in promoting the sale of educational software. Educational software firms recognize this (though some more than others, see Part III of this report).

Willingness-to-pay is one mechanism an economist can employ to better understand the consumer surplus associated with a good but this only applies to goods where the value is well perceived. More traditional products have a perceived value built up over time and experience. Unfortunately teachers and administrators have not the experience base with new products.

One way to improve perception of value is through communicating the perceived value between groups perceiving value and those not.

Policy Option Recommendations Regarding *Low Perceived Value*. One of the ways the federal government can increase perceived value is through model projects. These projects are aimed not so much at trying experimental software but rather at incorporating highly respected software to gain an experience base. The government has had successes in this type of policy, for example, the model cities program. An important component of the program is information transfer. And one of the best ways to achieve information transfer is through the transfer of people. Thus, the funding for such model projects should include monies to provide teachers and administrators with transit and lodging. Choices of those participating should be made on the basis of identifying schools where perceived value is particularly low.

School System Hindrance

All firms agree that the complexities of doing business in the school market are enormous and lead to high transaction costs. Firms such as IBM try to reduce this by primarily dealing with the largest school districts, ignoring the smaller ones.

As discussed above, while some of the problem is simply bureaucratic, the main reason goes to the complex process required to make decisions at the local level, in particular, to make sure that "voice" is internalized.

The only examples where transaction costs have been substantially reduced are in instances where the state provides aggregate demand. Thus in the case of Tennessee, the requirements for

Apple computers in all schools aggregated the market and reduced transaction costs.

Policy Option Recommendations Regarding *School System Hindrance*. There is little the federal government can do about this problem because it is endemic to the structure of the school system. States (because of their authority over local school systems) can aggegate the markets either through 1) requirements (as in the case of keyboard literacy requirements in Texas), and 2) procurement (as in the case of Tennessee). These are very effective and have made substantial differences in those states.

Duplication of Effort

Most educational software firms agree that there is duplication of effort in the industry. Some firms believe it is excessive while others see the different features as providing the buyer with better choices and more features.

Without further study it is difficult to separate out these statements. It is true that no matter how much excessive duplication there is, each item will provide some incremental increase in consumer choice. Certainly the state-of-the-art of the industry suggests there are many parallel efforts where few are building on the progress of others.

Policy Option Recommendations Regarding *Duplication of Effort*. The major way government has prevented duplication of effort in the past has been through coordination and procurement. NASA's space exploration took the efforts of many different contractors to achieve the goal. Defense procurements are of a similar nature. France has coordinated the computer terminal market. Nonetheless, this country has rarely attempted to coordinate the market outside of defense and space exploration and it is doubtful that this market would be an exception.

Poor Legacy

If veneration and perceived value are difficult to overcome, the sense of computer software as legacy is even more difficult. Determining the extent legacy should be considered is as unfathomable as determining the value of human life. While human life has been termed by some as *priceless*, everyday allocation of health care resources make it clear that there are limits to what is spent to save a life.

Policy Option Recommendations Regarding *Poor Legacy*. Government, per se, has little direct role in establishing legacy. It will respond to senses of legacy in society but it is not normally empowered to establish it. Nonetheless, one of the roles of national political leaders is to provide purpose and national direction and as part of that a sense of legacy can be established. Thus, policies for legacy are bound with leadership and are discussed below.

Poor Equity

One of this society's most enduring commitments has been to equity. Evidence shows that particularly when there are fewer microcomputers than students, that boys tend to overwelm and get greater access to machine time [Knupfer, 1986]. Also, school districts with more affluent families have exercised more voice to have computers in the schools, than districts with less affluent families. The state role in this regard is described by Fantini [1983].

Policy Option Recommendations Regarding *Poor Equity*. The federal government should monitor for differences in equity in the provision of hardware and software, and use either regulatory requirements or subsidy to improve equity.

Lack of Leadership/Vision

The lack of leadership and/or vision is a fundamental way the patron fails to meet the needs of the nonprofit-market system. In the case of educational technology the most serious failure is political leadership.

As discussed at the very beginning of this report, the lack of political leadership parallels a lack of purpose and direction in American society and American economy. We are behaving, in the Abernathy-Utterback model of innovation (see Part III) like a mature firm that has lost its ability to do product innovation and instead concentrates on process innovation, e.g. making detergents cheaper or slightly changing their bleaching characteristics, etc.

Unfortunately, as is now popularly known, our labor rates confound our abilities to keep pace with the lower labor rate countries in the area of process innovation. This is because, given the current state of robotic technology, we are not able to substitute capital for labor fast enough to remain price competitive with lower labor rate countries. This imbalance will not last forever, and as our mature firms accelerate the substitution of capital (robotics, automation, expert systems, etc.) for labor, we will regain a balance of trade. However, this is not the main theme of our country which has been to be world leaders in new and innovative products.

The new technology provides our country with an opportunity for innovations that will likely dwarf the advances made with mechanization and the introduction of electricity. These advances, however, are not of the same type and character as mainstream American industry, and many are blind to what it entails. The various activities associated with Stevenson-Wydler and the National Cooperative Research Act is mostly more of the same industrial focus that has dominated the last fifty years. Reducing antitrust concerns is mainly of interest only to giant industries that are close to monopoly control in some markets. But these large-stakes, big industrial market arenas are not the locii for innovations in educational technology and information technology in general.

These technologies are technologies of the heart. That is, they are about people — how well they can think, how comfortable they are with the world around them, how well they can manage relationships with others, and ways they can communicate. So far our greatest advances in information technologies have been entertainment — the movie industry. This industry has grown and made tremendous strides in being able to create "synthesized experiences." They have been so successful that many of the population are "certifiably" addicted to movies and television. That is, these people achieve a sense of wellbeing and vicarious emotion from these synthesized experiences and cannot comfortable live without them.

Information technologies that have a one-on-one character such as computers, hold the promise of changing the balance of information activities. They will provide specifically instruction, guidance, and sense to each individual as he or she is attempting to adapt and grow in society. The technology empowers individuals to achieve what they want and need and by so doing encourages personal industry and accomplishment. Further, through networks of information systems, there will be the opportunity for guidance and feedback that reduces conflict and increases harmony — not in a coercive way but in a voluntarily informing way, like the advice of a good friend.

It is these technologies that provide the opportunity for America to be first again in the application of technology to providing an improved standard of living and economic growth. It is this sense that political leadership needs to communicate to the country. [See further Part V, Appendix A, *Perspective on Educational Technologies*.]

Unlike technologies like the light bulb and the automobile which were patentable and tangible, the new technology and its effects are unpatentable, intangible, under perceived in value, and their potential capability unknown. Therefore, unlike a previous era where buyers readily bought new products, in this era products are not readily bought — progress is frozen by the thirty forms of nonprofit, market, and patron failures identified in this report.

A few political leaders have led an unsuccessful fight for greater Congressional attention for educational technology. These include the efforts of Senator Albert Gore and Rep. George Brown. However, their bills and hearings were stymied by two problems: 1) the lack of a clear framework and perception of the actual system failures, and 2) a lack of a clear perception of the nonprofit, market, patron system. The second problem led to bills that pretended the nonprofit sector didn't exist and that the problem had to be solved by more intrusive forms of federal government, e.g., a National Center for Software.

Earlier we mentioned the few numbers of intellectual leaders and the difficulty for people such as Seymour Papert, Alan Kay, and Mary Alice White to carry all the load of intellectual leadership. Secondly, educational technology advocates such as Ludwig Braun, Alfred Bork, David Moursund, Gregory Benson, Frank Withrow, Arthur Melmed, Marc Tucker, and Stanley Pogrow are also not able to provide a strong enough advocacy role without greater political support and grassroots constituency.

Hopefully, the tier of nonprofit organizations and government associated groups that are concerned about the failure of the patron (identified in the framework section) will provide the type of guidance that is needed to stimulate the political leadership required.

Policy Option Recommendations Regarding *Lack of Leadership/Vision*. The tier of nonprofit organizations and government associated groups, including the Office of Technology Assessment, should promote the level of national discussion and attention required to raise political leadership to the fore. This will occur, especially, when the connection is made between the capability of the technologies and solving our national problems of trade, foreign affairs, education, family discord, youth apathy, etc. Seed monies are needed to fund this coordinative effort and discussion. Unlike some national problems with sufficient grassroots recognition, this particular problem requires initial funding from sources of sufficient wisdom to 1) understand the nature of the nonprofit, market, and patron failure, and 2) recognize the potential for educational technology and information technologies in general.

Diversion to Other Issues

At the national level there has been considerable diversion of political talent to a number of issues, none of which are very synergistic with the need for leadership in educational techhnology. Some are unfortunate crises such as Iran and AIDS. Others, like the tax overhaul has been the result of long standing political pressures and fiscal policy needs. Perhaps the most misplaced efforts, however, have been the preoccupation with trade policy and international competitiveness. These efforts are misplaced because they have a vision of an industrial America based on the past, not the future. Aside from information technology, there are only a few other vital industrial frontiers (biotechnology, robotics, and advanced materials, e.g., superconductors) that can drive an economy based on product innovations. Otherwise, most other industrial areas are well into a mature incremental innovation stage which do not hold promise to solve our problems of international competiveness.

Policy Option Recommendations Regarding *Diversion to Other Issues*. There needs to be a redirection of the sense for economic America. With this awakening, attention to educational technology, and information technology in general will receive national prominence and attention. As in the problem with leadership and vision, the nonprofits and government groups that are concerned about failure of the patron must press to correct the situation.

Inbreeding

Earlier sections have described the serious problems of inbreeding both associated with the NIE operated Regional Educational Laboratories and with the peer review system used, in particular, by the National Science Foundation.

The major problem with inbreeding is it is antithetical to the innovative process. Innovation involves entrepreneurs and mavericks, people who don't usually fit in and who can step back from the world and events and do something different and useful. Thus, unless such a person manages to become known and accepted within peer review circles, they and their proposed work are systematically discouraged by peer review. See for example the series in the *Boston Globe* on mavericks in science and the peer review problem [June 22-23, 1987].

Programs such as SBIR (described above) are particularly vulnerable to the use of peer review systems by agencies that have traditionally reviewed academically based proposal within academic peer review systems.

Policy Option Recommendations Regarding *Inbreeding*. To reduce the problems of inbreeding, the first step is to require accountability on the problem. Important funding sources such as NSF and DOE should be required to provide a clause in their procurements, to the effect that, "If in the case of an unsuccessful offer, the submitter believes the proposal has been discriminated against because of an inability of the review system to appreciate or understand the innovative character of the proposal, the submitter need not wait for another grant or contract cycle but may immediately submit an appeal to the agency (foundation) providing a written statement of the innovative character of the proposal. If in 60 days of discussion, the problem cannot be resolved satisfactorily, a new review group will be assembled within 60 days, chosen by the agency (foundation), and half of the members must meet the approval of the submitter. If after 90 days the new review group, the agency (foundation) and the submitter have not resolved the problem, the submitter may appeal the problem to the National Review Board for the Encouragement of Innovation in Science and Technology for resolution."

The second step is to make specific awards of funding and subsidy less dependent on peer review and reduce the support of directly funded laboratories. A number of suggestions in earlier

sections of this report suggest ways to rely more on the nonprofit sector to identify and encourage innovative activity, either by increasing recognition on the part of schools for the technology or by promoting innovative enclaves that will be the source of intellectual leadership as well as innovations. The role of the nonprofits that have formed to remedy forms of patron failure could be provided review roles for the allocation of federal funds to innovative projects. Accountability could be maintained by requiring the nonprofit to submit detailed evidence of the positive effects the nonprofit has achieved in the past. This frees the nonprofit from having to justify a current decision and will weed out those nonprofits that are just giving money to their friends. The form of evidence might include written statements from schools that have been favorably impressed, by intellectual leaders, and other significant parties that are interested in the results.